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SKY HIGH

Wide World

WHERE IT ALL BEGAN

The Shaft That Marks the Spot Where the Wright Brothers First Began Experiments With Their "Strange Contraption" (*Page 180*)

SKY HIGH

THE STORY OF AVIATION

By
ERIC HODGINS
and
F. ALEXANDER MAGOUN

ILLUSTRATED

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To the memory of those persistent gentlemen who, since the recorded history of flight began, were always quick to assert that It Could Not Be Done — in the hope that this story of courage and sacrifice may make them turn, now and then, uneasily in their graves

15131

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E. H.
F. A. M.

Boston, *September* 1929

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I

IN THE BEGINNING

EARLY in the march of civilization man found that he had conquered two elements. The land and the water were his to travel on, but the invisible and mysterious air he could not conquer. His triumph was incomplete.

For this reason the birds annoyed him. They made flight seem so easy and so effortless. They could soar and he could only envy. To cover up this envy he convinced himself that the ability to fly was supernatural. He built up pleasant fables of winged horses, of magic carpets, and of flying gods.

After countless years man began dimly to realize that if he really wanted to fly he must do something more than merely speculate; he must try out his ideas in a practical way and see whether any of them worked.

The first historical record of mechanical flight is bogus, but at least it began, as it quite properly should have, with experiments on a model. In the fourth century before Christ lived Archytas, a learned man of Taranto. He was a scholar of geometry — a student of Pythagoras. He constructed a wooden pigeon, or dove, which is reputed to have flown by means of mechanical power plus "hidden and enclosed air" — a mysterious substance also described as an "aura of spirit." In the various cryptic descriptions which still remain, the machinery is vaguely explained, but the forces that held it up and pushed it forward are attributed to occult powers — with

no apparent protest from contemporaries. The pigeon, it seems, could fly, " but if it fell, it could not lift itself up any more."

There are records, too, of the supposed flight of men. In the days of Nero, some unidentified Roman is supposed to have lifted himself high into the air with wings, only to lose his life in the descent. Antonius Byerlink, who recorded the adventure, worked nobly to make his account convincing, but the mechanism which he described was, of course, quite incapable of flight.

But the desire to travel through the air persisted. Wiser men began to give the idea some attention. Roger Bacon, born at Ilchester in 1214, was among the first of these. He was a man whose ideas were hundreds of years ahead of his time. In the thirteenth century he wrote of things which were not accomplished until the twentieth — of contrivances of great size and power which would travel over land and water at great speed carrying men and merchandise. He suggested that the air was a substance which could be made to support a properly designed aeronautical machine just as water buoys up a ship. " Such a machine," he said, " must be a large hollow globe of copper or other suitable metal, wrought extremely thin, in order to have it as light as possible. It must then be filled with ' ethereal air or liquid fire ' and launched from some elevated point into the atmosphere, where it will float like a vessel on the water." He had, you see, the idea, which persisted for more than four hundred years thereafter among scientists, that the earth's atmosphere had a sharply defined upper limit; that some miles above the earth the air ended and presented an upper surface; and that upon this surface an " aerial vessel " would float.

Bacon also thought that there might be some " flying instrument, so that a man sitting in the middle of the instrument, and turning some mechanism, may put in motion some artificial wings which may beat the air like a bird flying." In short, he definitely foresaw the balloon and what eventually developed into the airplane. And although his theories on both were wrong or impracticable in important respects his " ethereal air " and " liquid fire " do bear curious resemblances to the hydrogen and the hot air which were to be the buoyant forces in the balloons not destined to be invented for more than five hundred years.

You will get an insight into the historical accuracy of some early writers if you consider the case of Johann Müller. He is supposed to have invented an " iron fly " — no small achievement. That story we cannot deny, except by common sense. His other experiment is more easy to deal with. He is said to have built a mechanical eagle at Nuremberg, which flew to meet the Emperor Charles V on one of his victorious returns to the city. Having met the Emperor, the eagle then flew back again. It is a pretty story, and there is only one trouble with it. The Emperor Charles V was not born until the year 1500, and Johann Müller died in 1476.

Some twenty years before Johann Müller died, a great man was born. He never achieved flight, but he thought about it; pored over the idea and filled notebooks with designs and sketches. He was Leonardo da Vinci, who not only was one of the greatest masters of the high Renaissance as a painter, but was also a sculptor, an architect, an engineer, and a scientist. Like Roger Bacon, he proposed a sort of flying machine. He was more definite than Bacon; his idea was that man could construct and apply to himself a pair of flap-

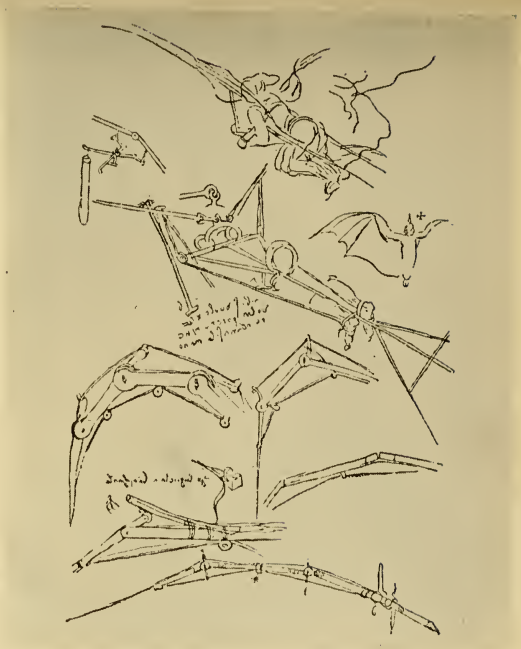
ping wings in direct imitation of birds. It seemed to him at first that the arms alone should actuate the wings, but on reflection he very rightly decided that much more power would be necessary; his later sketches consequently showed apparatus in which the wing was thrust downward by the leg muscles and raised by the arms. His idea was never put into practice, but it was the forerunner of many actual experiments, every one of which ended, as it was foredoomed to do, in failure. Da Vinci and the hundreds of others who came after him failed to realize that man's muscles are not nearly as strong in relation to his body weight as are those of a bird. If a pigeon weighed fifty-seven pounds, it would be strong enough to exert a full horsepower; if a sparrow weighed forty-nine pounds, it could do the same. Yet at best a man who weighs one hundred and fifty pounds can exert a horsepower for only three or four seconds. When he must sustain his efforts, he can exert no more than an eighth of this amount. Nothing could more clearly demonstrate the impossibility of expecting man to fly by flapping his arms. Neither Leonardo da Vinci nor any of his followers for many years had the benefit of sufficient observation of birds and mathematical studies of their flights to realize all this.

Most people think that the aerial screw is an adaptation of the marine propeller. It is true that the marine propeller came into practical use one hundred years before the aerial screw — but Leonardo da Vinci invented the screw in the middle of the fifteenth century! He made many experiments with small models carrying paper propellers which acted on the helicopter principle, i.e., of lifting their load *vertically*. Da Vinci's models actually flew with considerable success; from this starting point he went on to the design of full-scale

Smithsonian Institution

ARCHYTAS

He Who Flew the Wooden Pigeon
(*Page 3*)



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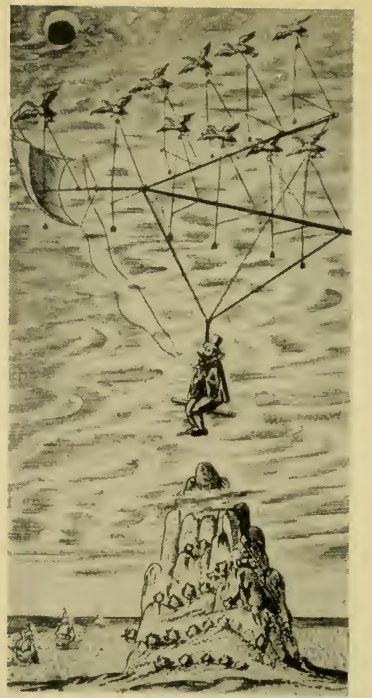
NOTEBOOK SKETCHES

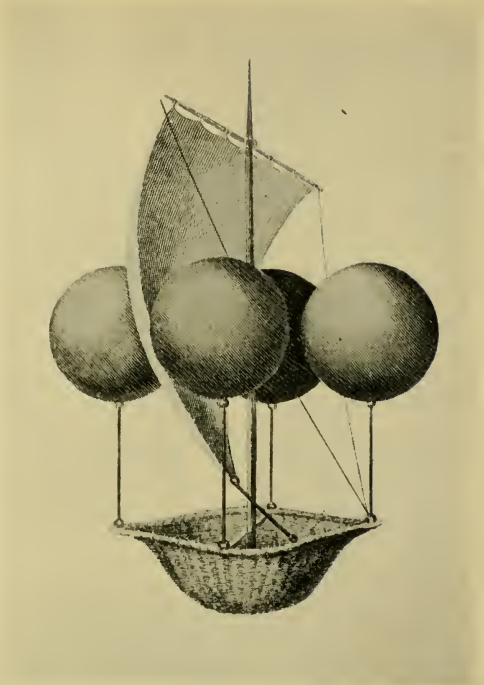
How Leonardo da Vinci Recorded His Thoughts on Human Flight (*Page 5*)



Vail Collection

THE VOYAGE OF DOMINGO GONSALES

Imaginary, Yet One Man Aspired to Fly This Way



Vail Collection

LANA'S AERIAL SHIP

He Sought to Fly With Copper Spheres and a Sail (*Page 8*)

machines, and his notebooks contain sketches for a machine ninety-six feet in diameter. The framework was to have been iron and bamboo covered with linen, heavily starched to make it impervious to air. Despite his sketches, Da Vinci abandoned the idea of constructing his machine — probably because he came to realize that the amount of power which would be required for its operation was far beyond the capacity of any source then known.

After Leonardo da Vinci, who, although he happened to be wrong, nevertheless brought a really discerning genius to bear on aviation, the fogs close in again. The world had once more entered an age in which men preferred talking about things to trying them. The brave beginning of what we now call the laboratory method (which means only trying things to see if they will work) had died out. Scientific gentlemen of the Middle Ages would give solemn instructions on how to escape the dominion of gravitation, but these were based only on their beliefs, and their beliefs were usually based on nothing. They knew, for example, that an eggshell is light. They knew also, or thought they did, that the disappearance of dew in the morning was the work of the sun, which "drew it up" from the earth. Putting these facts together, they stated that if eggshells were filled with dew, and then exposed to the sun, they would rise — and that all a man needed to achieve the art of aerostation (here is a word that went out of date in common use not more than a dozen years ago) was enough eggs and enough dew. He could hitch himself to the eggs. But there is no record that anyone ever tried this, which is perhaps just as well.

Then there was John Wilkins, Lord Bishop of Chester. He was full of ideas on how one might fly. He repeated

Roger Bacon's idea, adding a few ingenious touches of his own. If some metal vessel were filled, he thought, with a kind of lighter air, it would float on top of the atmosphere as a piece of wood does upon water. And some sort of watch spring might drive it. Later, this helpful Bishop listed four ways in which men could achieve flight. They were: first, with the spirits of angels; second, with the help of fowls; third, with wings fastened to the body; and fourth, with a flying chariot. Yet this Bishop Wilkins had vision. He would not, he said, be surprised if, in the course of years, men were to call for their wings as frequently as they called for their boots. Before the development of aviation is over, the prediction of the Lord Bishop of Chester will have been made good — even if in a fashion which he could never have anticipated.

And so we come to Francesco Lana, a Jesuit, who deserves credit for one thing at least: he was the first man in history, if we except Roger Bacon (whose ideas were great but vague), to propose a lighter-than-air machine on principles that had some basis of fact.

The practicalities were all against him. His device never had the remotest chance of success, but at least physical theory was on his side. Why, he thought, can I not construct some hollow copper spheres, so light and thin, but so large, that when they are exhausted of air they will be lighter than the air they displace, and will therefore rise? And why can I not build four of them, attach them to the four corners of a car or carriage, and supply a sail which will carry the whole device along as a boat is carried at sea?

So he set himself to figures and actually went so far as to calculate that his spheres would need to be made of copper

shell only $\frac{1}{225}$ of an inch in thickness, but twenty feet in diameter. At that point he seems to have rested from his labors.

If Lana had carried his calculations to a logical conclusion he would have made an interesting discovery. He admitted that he had some doubts over the effect of the pressure of the air on his spheres, but he thought that, because of the shape of the metal shells, the pressure would tend to "consolidate" the metal. As a matter of fact, copper shells $\frac{1}{225}$ of an inch thick and twenty feet in diameter would collapse like tissue paper under their own weight. And into the bargain the total external force of the outside atmosphere on the four vacuum globes would have been 2,712,960 pounds.

Do not despise poor Francesco Lana too much. After all, the year of his aerial ship was only 1670, and the barometer itself had been invented only twenty-seven years earlier. Few people really understood its significance. Even in the nineteenth century, two attempts were actually made to construct a "vacuum balloon"; one was to be of light silk, held in shape by an inside framework; the other, designed by Marey Monge, was a duplicate of Lana's theoretical ship. The misguided builder spent, in 1845, twenty-five thousand francs before the absurdity of his efforts became evident. He, at least, lacked the consolations of Lana, who soothed himself with this reflection: "Other difficulties I do not foresee that could prevail against this invention, save only one, which seems to me the greatest of them all, and that is that God would surely never allow such a machine to be successful, since it would create many disturbances in the civil and political governments of mankind."

But by the beginning of the seventeenth century the idea

of what Bishop Wilkins called a " flying chariot " was to take so firm a hold on man's imagination as never again to be shaken off. The most absurd of these ideas were usually the most picturesque. Take the example of the Portuguese friar, De Gusman, who imagined one that was nothing less than magnificent, and applied to the king for a patent on it. De Gusman's chariot was to be a paper kite in the form of a bird and was to be equipped with tubes through which the wind could pass to fill a sail and propel it. It was to carry bellows, which would function when the wind was insufficient. To this marvel of propulsion there was to be attached a lifting device equally gifted. The electric attraction of pieces of amber was relied on for the lift, with the help of magnets placed at the top of the whole magnificent contrivance. Perhaps there has never been a finer example of a machine that would lift itself by its boot straps, but it did very well for the friar; it brought him a professorship in the College of Barcelos and a pension of six hundred thousand reis. Later on, however, he seems to have become entangled in some accusation of witchcraft — at which he had certainly made an excellent start.

Our record of man's desire to fly has already covered twenty-one centuries — from the pigeon of Archytas, four hundred years before Christ, to the chariot of De Gusman in the middle of the seventeenth century A.D. Yet we have found no really plausible story of actual flight by man, and we have read of no one but theorists — men sometimes great, like Roger Bacon or Leonardo da Vinci, and sometimes foolish, like Friar de Gusman, but always men who preferred thought to action. We now meet our first successful *experimenter*.

He was a French locksmith by the name of Besnier. Like

so many other envious humans, he had watched the flight of birds, and by the year 1678 he had determined that he would imitate them. So he built himself an apparatus which consisted of two wooden bars, to rest upon his shoulders. At the ends of these bars he placed muslin wings. He designed the bars to be pulled up and down by his arms and legs and arranged the wings so that they opened flat on the downstroke and folded vertically on the upstroke.

Now the flapping of his wings was of no possible use as an aid to flight. Besnier was senselessly proud of this feature, with a pride that did, later, seem to be justified. The truth, as we know it now, is that Besnier had the great good fortune to hit upon the first crude design for a glider. He had the astuteness, this locksmith, to realize that he could never hope to rise from the ground under the power of his own muscles. Wisely he began in the other direction; he jumped from scant heights and used his wings to carry him as far as possible before he landed. First, he jumped from a window sill; then he jumped from a second-story window; at last he screwed up his courage and jumped from a garret.

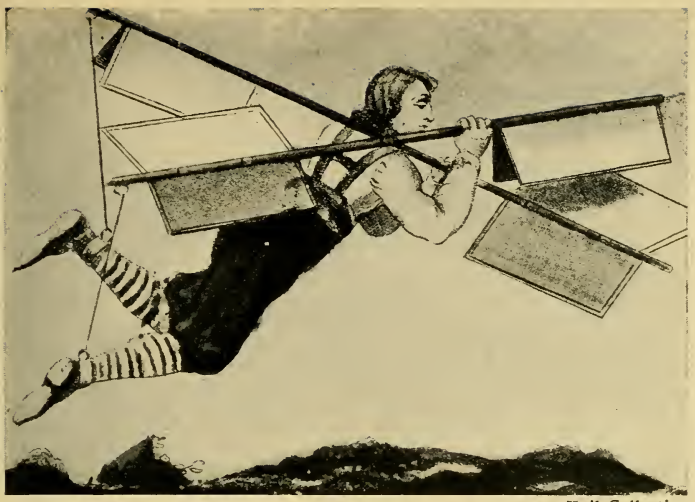
This final flight was reported to be an astonishing success. Besnier soared over the roof of a near-by cottage and landed safely on the ground. After he had tasted triumph, his next move was the really crowning feat of his career. Still whole in all his limbs, and with a record untouched by failure or catastrophe, he retired from aviation and sold his apparatus to a traveling showman.

And so in the seventeenth century we do find the first authentic story of man's flight. Disaster preceded it; disaster followed it again. Before Besnier a tight-rope walker who lived during the reign of Louis XIV and whose name was

Allard had built a similar rig and tried to fly from the terrace of St. Germain toward the woods of Vésinet. This show of courage was by way of entertainment for the monarch. In Louis's eyes the performance was probably judged a success; Allard almost killed himself. The science of aviation was not, however, advanced.

Then Besnier made his flight, and the seventeenth century ended without much further aeronautical distinction. Public opinion was scarcely encouraging. Small wonder that there were not too many aspirants to follow in the footsteps of the locksmith. Hordes of persons had risen up to point out the reasons why flying was not only hazardous but highly undesirable, not worth the effort, and probably to be prevented by statute if necessary. Addison, the essayist, was one of these. He had no faith in the art of flying and said that he " resolved so far to discourage it, as to prevent any person flying in my time." His chief objection turned out to be the evil influence " it would have on love affairs." He went on to explain this rather difficult bit of logic. " It would fill the world with innumerable immoralities, and give such occasion for intrigues as people cannot meet with who have nothing but legs to carry them." That was in the happy days before the automobile.

The eighteenth century was almost half gone before another spectacular attempt at heavier-than-air flight was made. This was the heroic gesture of the Marquis de Bacqueville. In 1742, he announced that he would fly from his mansion on the Rue des Saints-Pères across the river Seine to the Tuileries Gardens — some five or six hundred feet away. Duly, a large crowd gathered. They could see the Marquis with large paddle-shaped wings attached to his hands and



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THE LOCKSMITH BESNIER

History Records Him as the First Successful Flier (*Page 11*)

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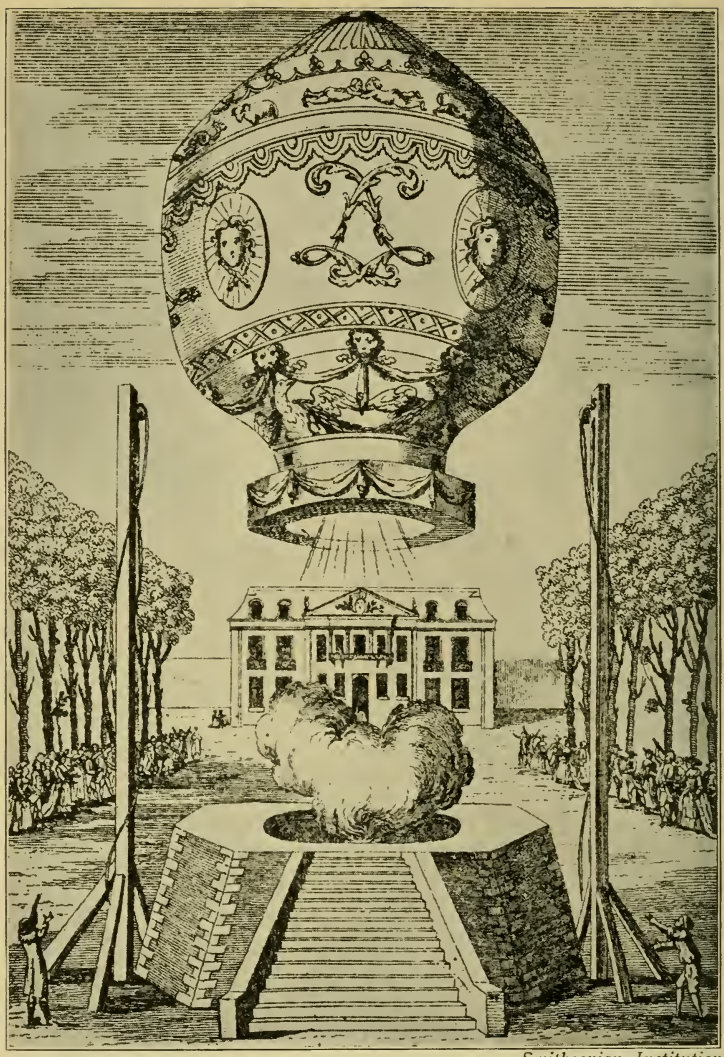
THE MARQUIS DE BACQUEVILLE

He Fell Onto a Washerwoman's Barge (*Page 12*)



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"GLOBE AEROSTATIQUE"

The Fire Balloon Was the Invention of the Brothers Montgolfier
(*Page 16*)

feet. The machinery of his flight seemed none too convincing; but the crowd waited patiently, confident of the success of the nobility in performing miracles.

Perhaps the same idea buoyed up the confidence of the Marquis, but the Marquis himself it did not buoy up. He jumped; his arms and legs beat the air frantically. For a moment he seemed to make progress; then he faltered and fell, not into the soft waters of the Seine, but, alas for nobility, onto the deck of a washerwoman's barge anchored in his path. He broke his leg. What happened to his pride was not recorded. He never flew again.

Almost never does successful achievement come about as the result of deliberate means. Someone studying an entirely different problem comes, often unknowingly, upon a secret of whose importance he may have no conception. Twenty-four years after the Marquis de Bacqueville fell with an aristocratic thump upon that barge in the Seine, the stage was suddenly set for the successful beginnings of "aerostation." For in the year 1766 the English chemist Henry Cavendish, busy in his laboratory, poured oil of vitriol over some scraps of iron. A gas was evolved which Cavendish captured, weighed, and called "inflammable air." It was hydrogen, known before, but never carefully studied. Henry Cavendish knew little and cared less about aerostation, but he made it possible. Even though the first discoverers made no direct use of his facts, he established a principle which is in use to-day.

A few years after this, it occurred to the physicist Joseph Black, of Edinburgh, that since this new gas was obviously lighter than air it was probable that some sort of sac filled with it would rise. He actually had such a sac made, and

then, for some strange reason, with the secret of man's first method of navigating the skies in his easy grasp, he turned to something else. He never made the one experiment that would have made his name immortal.

As it is, Tiberius Cavallo, a distinguished Italian scientist who lived in England, gets the credit for being the first man with enough curiosity to study this new "inflammable air." He blew soap bubbles with it and amused himself by watching them rise swiftly and burst against the ceiling. Then he, too, paused, thinking of nothing else to do with this new gas that Henry Cavendish had made.

Meanwhile, in France, two reflective brothers watched the smoke from their fire ascend the chimney and asked themselves questions, first idle, later full of purpose. Although the theory they believed in was entirely wrong, chance sided with them, and the thing happened.

II

THE THING HAPPENS

The brothers Montgolfier began to think seriously of an "aerostatic machine" toward the middle of 1782. They were then young men: Joseph, the elder, born in 1740; Etienne, whose name in English would be Stephen, born in 1745. They lived in the little town of Annonay, France, where their father had a prosperous business, a paper mill, from which he had retired, leaving the enterprise in their hands. That mill still stands and operates to-day.

The brothers had not been brought up for this business; mathematics, chemistry, and natural philosophy had been the studies of their youth. Only the death of an elder brother brought the responsibilities of the paper mill upon them. They did not permit this turn of chance to divert them, for they were naturally reflective; and, as men were beginning to do, they turned their reflections toward some of the simple facts of the world in which they lived.

One evening, as he sat drowsing before his fire, it occurred to Joseph that if the smoke from the smouldering logs were eager to escape upward through his chimney it might not be at all impossible to persuade the smoke to carry something with it. This was exactly the kind of idea that had occurred to Dr. Joseph Black, but whereas Dr. Black lost interest, Joseph Montgolfier became possessed of his idea and could think of nothing else. He spoke to Stephen about it, and

Stephen agreed that there was probably much in it. He even pointed out the levity of clouds, and how they floated placidly in the sky, buoyed up against the pull of gravitation. He went further: he proposed that they set out "to capture a cloud in a bag"—apparently with the idea that the cloud would oblige them not only in being caught, but in offering its buoyancy on demand. After this noble idea, Stephen's inspiration seems to have broken down; there is no record of how he proposed to stalk his cloud. So the brothers went back to Joseph's original idea of harnessing the smoke of the chimney.

Once he had decided upon his plan, Joseph moved with commendable speed along the trail. He believed that smoke would buoy up a bag containing it on the theory that burning substances developed a gas which was itself lighter than air; he had no notion that his real principle (which Lana had explained, but the world had forgotten) was that heated air is lighter than cold air because a gas expands when heated and contracts when cooled. Herein he made his classic mistake and misled the savants of Paris, but his first machine (the term "balloon" was rarely applied to his invention) was no less a success.

At Avignon in mid-November, 1782, the two brothers scored their opening triumph. It was private. For more than six months the world was not to know of what had happened. In odd moments they constructed a bag of fine silk; not, as you would imagine, spherical, but in the form of a rough cube. It had a capacity of about forty cubic feet, so that it must have been between three and four feet long on each side. At the bottom they left an opening. When the great moment came, Joseph applied burning paper just below it and allowed the smoke to enter the bag. With a grati-

fying speed the bag swelled into the shape of an awkward sphere, and sailed to the ceiling of the room. Cavallo's soap bubbles had a successor, and the Montgolfier brothers were the possessors of the most precious thing on earth — a realized dream.

They moved with caution. They had the true spirit of the scientist and were anxious that no one should know of the experiments until they themselves were sure that success was based upon something more than a fluke. So they said nothing, wrapped the precious silken bag up tight, and journeyed back to Annonay. There, free from overcurious onlookers, Joseph and his brother tried the same experiment again — with the important difference that this time they worked outdoors. The silken bag obliged by swelling out just as before and by rising seventy feet into the air. Then it fell slowly and gently to their feet. Triumph!

It seems simple, now. But remember that the year was 1782. George Washington was not yet President of the United States, whose independence had been acknowledged for only a few months. Napoleon Bonaparte was a boy of thirteen; it was to be ten years before the Reign of Terror began in France. That new invention, the steam engine, had not yet been put to any useful purpose. When you consider that this was the world of the brothers Montgolfier, you will realize that they were men in the front rank of imagination and ability, and that they had every reason to rejoice in their discovery.

They did not rest long on their laurels, but built a machine of 650 cubic feet capacity, and had the immense satisfaction of having it break its restraining ropes and soar 600 feet into the air. In April 1783, they built an even larger machine,

which once again broke its mooring ropes, went up 1000 feet, was caught by the wind, and came to earth over three-quarters of a mile from its starting point. Then, and only then, did Joseph and Stephen Montgolfier decide to show their invention to the world.

Two months later, the States of Vivarais assembled at Annonay and the brothers invited them to see the newest wonder in the world. There, on the fifth of June, 1783, in the presence of "a respectable assembly and a great multitude of people," the brothers went about their demonstration. Their machine was a huge bag of linen lined with paper, 110 feet in circumference when filled. This time the brothers had not denied themselves; the bag had a capacity of 23,430 cubic feet. If you compare this with the 2,500,000 cubic feet of a ship like the dirigible Los Angeles or the 6,500,000 cubic feet of the new ZRS-4, now being built, it seems ridiculously small. To the brothers and spectators it was enormous enough. The linen sectors were joined with buttons and buttonholes. For it was on the paper lining that Joseph and Stephen, trained to have faith in the efficacy of paper, relied to keep their mysterious vapor from escaping.

The brothers set to work in the market place, kindling a fire of straw and chopped wool under the aperture, telling the excited, incredulous, and somewhat panicky audience that soon the limp bag would become round and distended and that then it would soar straight upward at great speed. Everything went well. The straw and chopped wool supplied great quantities of poisonous smoke (no wonder Joseph thought he had discovered a new gas) and the bag, held over a hole in the ground into which the burning materials were fed, fulfilled all promises. Soon it took the strength of eight

men to hold it and the scoffers in the audience began to watch with a deal more interest.

The moment had come. Joseph gave the signal, the eight straining pairs of arms relaxed, and the " aerostat " shot into the air like a huge soft bullet. Six thousand feet it went up, by the measurements of careful gentlemen with " philosophical instruments," nor did it come down until it had gone a distance of 7668 feet from its starting point. Joseph and Stephen were heroes, and the rest of the day was given over to celebration.

The great news of the Montgolfier triumph was swift in reaching Paris and swift also in spurring the philosophers of the city to repeat the experiment for themselves. As soon as they set about ways and means, the error of Joseph in believing that he had discovered a new gas began its helpful work. The messengers from Annonay had assured Paris that " Montgolfier's gas " was responsible for the ascension and that experience proved it to be, volume for volume, only one half as heavy as air. Finally the obvious fact that had been waiting years for recognition dawned upon the savants of the Académie des Sciences. If the Montgolfiers had made an aerostat filled with a gas half as heavy as air, then the " inflammable air " which Henry Cavendish had weighed, and which was one fourteenth as heavy, seemed even more desirable. Discovery! The principle of the lighter-than-air machine was established.

The enterprising Faujas de Saint-Fond promptly set about raising money by popular subscription for the new project. He found it easy. Money for the construction of an inflammable air machine poured swiftly in. The two Robert brothers, who claimed to have found the means of making silk

gas-tight, were the constructors. The physicist Charles was in general charge and had the unheard-of task of producing enough inflammable air.

The balloon was finished on August 23, 1783. It had not been easy to build, for the simple linen and paper bag of the Montgolfiers would not hold the new gas. The task of the Robert brothers was to find some fabric sufficiently impervious, yet not too heavy. They made good their promise and constructed a spherical bag of a silken material known as lutestring, varnished with dissolved rubber. The bag was thirteen feet in diameter with an aperture and stopcock at the bottom and weighed some twenty-five pounds. This was the first contrivance to be called a balloon. The Montgolfiers' creations had not been globular and had come to be called, in their honor, Montgolfières.

It now fell to Professor Charles to get the globe of the Robert brothers filled with inflammable air. The ascension was to take place on August 27, 1783, and he had thus four days' time for the actual filling. It must be confessed that the learned professor did not appear any too successfully in the guise of an aeronautic technician. His method of producing hydrogen was of course the classic one of reacting a metal with an acid. The metal was iron and the acid dilute sulphuric. So far, so good. But for some peculiar reason Professor Charles had for a generator an apparatus looking rather like a chest of drawers, with four or five separate lead-lined compartments for the reaction. All of these led to a common pipe, which was fastened to the stopcock of the balloon. With all these magnificent opportunities for leakages, it is no wonder that most of the hydrogen escaped gayly into the air, and that after six hours the workers had produced very little

effect on the silken bag. At two in the afternoon Professor Charles abandoned his chiffonier and substituted a much more sensible generator: a single cask set upright with one hole in the top to put in the acid and iron and another for the hydrogen to come out. After that, things went better, although everyone was shocked at the amount of raw materials necessary. The distracted professor had already used a quarter of a ton of sulphuric acid and half a ton of iron filings.

His worries were not over by any means. The reaction of the cask generated a great deal of heat and even the balloon began to show signs of fever. A corps of workmen had to be detailed to pump water over it to keep it cool. Then, too, water vapor was continually being carried into the balloon with the hydrogen and every so often activities had to be stopped to drain it out. By nine in the evening, after thirteen hours of frantic work, the balloon was less than one third filled. Everyone went home discouraged.

Next morning at daybreak, when Professor Charles and his crew appeared, there was the balloon, swelled to its full size.

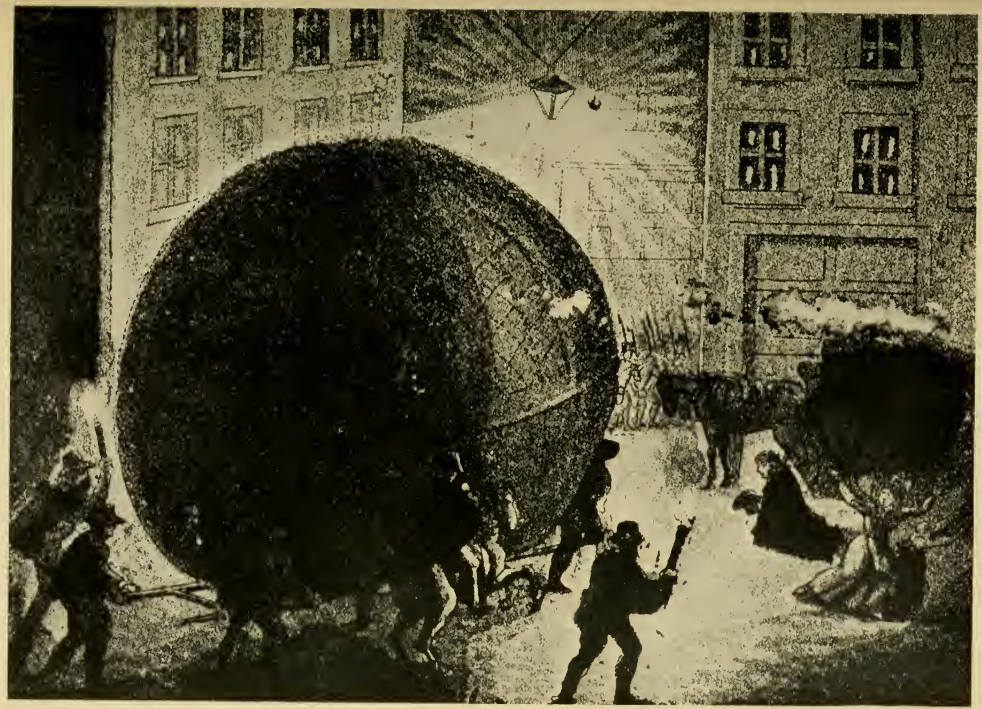
Something had happened. Something was seriously wrong. It shortly transpired that a careless workman had left the stopcock open the night before and that the outside air had entered and filled up the bag. The diluted hydrogen was useless.

What the professor, who must have been jolted somewhat out of his academic calm, said to the workman whose carelessness had undone all the work of the day before is, unhappily, lost to history. But, despite the disappointment, Professor Charles started all over again and, with the benefit of yesterday's experience, made good progress. In the evening he left a balloon which actually gave evidence of some desire

to rise. Next morning, August 25, the balloon showed even more buoyancy, and after that the workers confined themselves to small fillings and replacements of leakage. Later they amused themselves by letting the balloon up at the end of a rope and then hauling it down again. This brought such hordes of spectators that the balloon was saved from destruction only by a quick call for guards.

On the morning of August 27 began the procession from the Place des Victoires, where the balloon had been filled, to the Champ de Mars, where it was to ascend. Saint-Fond had thought to avoid crowds by starting before daybreak, carrying the filled balloon in a cart with a heavy guard front and rear. Torches lit the way. Nowadays, if anyone carried an open flame within a few yards of 22,000 cubic feet of loosely contained hydrogen, there would be an enthusiastic retreat from the scene. But this was a triumphal journey and luckily nothing happened, save that the crowds grew denser and the excitement higher with every step of the two-mile journey.

All day the crowds waited. Every avenue was clogged; every housetop sagged with a load of watchers. More than one hundred thousand people waited, that August afternoon, on the Field of Mars. After hours of delay, and much replacing of leaking hydrogen, the firing of a cannon at the hour of five in the afternoon signaled for the release of the balloon, which, says Cavallo, "rose majestically in a shower of rain." Within two minutes it had risen more than three thousand feet and become lost in a dark cloud. It appeared again for an instant and then vanished — to fall later at Gonesse, fifteen miles away, much to the disrelish of the natives, who did not see why large objects should fall on them



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TRIUMPHAL JOURNEY

The First Hydrogen Balloon On Its Way to the Champ de Mars (*Page* 22)

Smithsonian Institution

ASCENT

The Montgolfière Which Rose from Versailles in the Presence of the King and Court of France (*Page* 22)

Vail Collection

DESCENT

The First Charlière, Attacked by the Infuriated Natives of Gonesse (*Page* 23)

from the sky unless the Devil had had something to do with it. So, after their terror had subsided, they shot it dead, attacked it with pitchforks, and finally tied it to a horse's tail and galloped it about until nothing but shreds remained.

After that, the government decided it would be well to say a word or so about the likelihood of balloons: "Anyone who should see such a globe, resembling the moon in an eclipse, should be aware that, far from being an alarming phenomenon, it is only a machine made of taffetas or light canvas, covered with a paper, that cannot cause any harm, and which will some day prove serviceable to the wants of society."

III

THE BALLOON TAKES PASSENGERS

The spotlight of history shifts back again to the gifted brothers Montgolfier. It was inevitable that they should receive scientific recognition and acclaim, and they did, swiftly. A few months after the experiment at Annonay, Joseph went to Paris and there appeared before the Académie des Sciences. The cautious Academy, in a burst of enthusiasm, offered him unlimited funds with which to repeat his experiments. Joseph built a bag seventy-two feet high, made secret experiments with it, and on September 12, 1783, scarcely two weeks after the ascension of the inflammable air balloon, demonstrated his aerostat to the fascinated scientists, who thereupon signed an affidavit to what they had seen. Among the signers was our own Benjamin Franklin.

Meanwhile, balloons had become the vogue that model airplanes are to-day. "Those anxious to derive a pecuniary advantage from the improvements of philosophy" — *i.e.,* manufacturers — began turning out miniature balloons in tremendous quantities. They swarmed into the air like gnats. The balloon, unlike many other inventions, did not have to force its way into a hostile world. It was spectacular and therefore it was welcomed with open arms.

The success of the Montgolfier experiment had been complete, and had brought still another triumph to the young in-

ventors. They were commanded to perform their experiment before the King and court of France.

For this great day they had planned to use the same machine that had convinced the Academy — an odd-shaped thing which had a middle that was prismatic, a top that was a pyramid, and a lower part that was a truncated cone. It was made of linen, covered on both sides with paper, and when it was filled it looked spheroidal — no small achievement for such a combination of shapes. This machine, however, met with an accident four days before the great demonstration, and Joseph was forced to set feverishly about the construction of another — smaller, but designed on the same plan. This he not only finished on time, but decorated remarkably. It was painted in gaudy, lavish water colors with elaborate traceries, ciphers, fleurs-de-lis, and what not. It looked, altogether, like the product of some mad paper hanger.

On September 19, 1783, at Versailles, Joseph went through his usual preliminaries, and at one o'clock released his great machine into the air for the benefit of the King and his assembled nobles. Here was another history-making voyage; for this was the first occasion on which any living earth-creatures had ventured into the air. As the first passengers in a balloon, history records a sheep, a rooster, and a duck; all unwilling, presumably, but first just the same.

The machine came gently down in eight minutes, thereby creating a problem for Joseph, who had assured his sovereign that it would stay up for at least twenty. But Louis was delighted with his afternoon; felt genial and not at all disposed to create difficulties. Joseph apologized, pointed to rents in the surface, undoubtedly due to hasty construction, and was assured that he was a great man. And so another milestone

went by in the rapid procession that had begun less than a year before. Joseph and Stephen Montgolfier, sons of Pierre, became, by royal decree, squires of France. Joseph was given a pension of two hundred dollars; Stephen received the Order of St. Michael.

Now the world waited for some brave pioneer to climb into an aerostat and ride up with it. The balloon, a year after its invention, struck everyone as a much safer and more reliable mode of flight than anyone considers it now. "The steadyness of the aerostat whilst in the air, its gradual and gentle descent, the safety of the animals which were sent up with it, and every other observation seem more than sufficient to expel any fear for such an enterprise." Perhaps. To-day it seems that, regardless of "gradual and gentle descents" and other boons, anyone willing to risk himself thousands of feet in the air in a machine made largely of paper and linen, and with a raging fire blazing in its carriage, must have been a hero of considerable stature. All the more should we honor Jean-François Pilâtre de Rozier, the first human being who ever left the surface of the earth.

It was he, a man of twenty-nine, who offered himself, a few weeks after the Versailles flight, as the first aerial traveler. The brothers Montgolfier promptly constructed an aerostat for his particular use. This one was seventy-four feet high and once again flamboyantly painted with fleurs-de-lis, signs of the zodiac, and so on. But, unlike any of its predecessors, it carried below its aperture a wicker gallery three feet broad with a balustrade three feet high. In the middle of this gallery hung an iron grate supported by chains from the body of the machine. It was in this that the aeronaut was supposed

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EARTH CREATURES IN THE AIR

The First Aerial Passengers Were a Sheep, a Rooster, and a Duck (*Page 25*)

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PROFESSOR CHARLES

The Inventor of the Hydrogen Balloon (*Page 20*)

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FRANÇOIS PILÂTRE DE ROZIER

The First Man To Be an Aerial Voyager (*Page 27*)

to maintain the fire that would sustain him in the air. The whole machine weighed three quarters of a ton.

On the fifteenth of October, the gallant De Rozier stepped gayly into the basket of the machine, waved away the restraining arms, and ascended. But this was not a free flight. At a height of eighty-four feet, the balloon was held captive by a rope. By throwing straw and wool into the grate, De Rozier remained aloft for four and a half minutes. Then he came down again and assured his friends that the experience had been pleasant, and that he could think of no inconvenience to aerial travel. To prove it, he did the same thing all over again two days later, for an even greater audience. By then the habit had him firmly in its grip. He went up at least a half-dozen times in the next few weeks in a captive balloon — later accompanied by Giroud de Villette. Then De Rozier made himself twice a hero. He determined that he should be the first man to attempt an aerial voyage.

From the gardens of the Château de la Muette in the Bois de Boulogne, on November 21, 1783, at fifty-four minutes past one o'clock in the afternoon, this first aerial voyage began. Pilâtre de Rozier and the Marquis d'Arlandes were the passengers, and they stepped jovially into the cage, like the brave men they were, despite a gusty wind that had all but wrecked the aerostat two hours before. There was no announcement of the voyage. Such, however, is the power of word-of-mouth advertising that a large crowd had gathered to see the start. De Rozier stoked his vile fire; the aerostat was released, rose, and began to drift northwest over the River Seine and over the heart of Paris. He and the Marquis doffed their caps to the watchers below and drifted out of sight. Courage is a strange thing. The Marquis, who shares with

De Rozier the honor of being the first man to experience sustained flight, was later broken for cowardice during the French Revolution.

And this is part of the letter which the Marquis d'Arlandes wrote to his friend, that same Saint-Fond who had raised money for the first inflammable air balloon:—

At this time M. Pilâtre said, You are doing nothing and we are not mounting. Pardon me, I replied. I threw a truss of straw upon the fire, stirring it a little at the same time, and then quickly turned my face back again; but I could no longer see La Muette. Astonished, I looked at the river. M. Pilâtre then said, Behold, there is the river, and observe that we descend. Well then, my friend, let us increase the fire; and we worked away. But instead of crossing the river, as our direction seemed to indicate, which carried us toward the Invalides, we passed along the island of Cygnes [Swans], returned to the principal course of the river, and advanced up as far as the Port de la Conférence. I said to my intrepid companion, Behold, there is a river, &c. I stirred the fire and took with the fork a truss of straw, which, no doubt from being too tight, did not take fire very easily. I lifted and shook it in the middle of the flame. The next moment I felt as if I were lifted up by my armpits, and said to my dear companion, Now we mount, &c. At the same time I heard a noise from the top of the machine, as if it were going to burst; and I looked, but did not see anything. However, as I was looking up I felt a shock, which was the only one I experienced. The direction of the motion was from the upper part downwards. I said then, What are you doing? Are you dancing? I did n't stir, said he. So much the better, replied I; it is at last a new current, which, I hope, will carry us away from the river. True enough, for when I turned myself in order to see where we were I found myself between L'École Militaire and les Invalides, beyond which place we had already gone about 2500

feet. M. Pilâtre said at the same time, We are over level ground. Yes, said I, and we advance. Work on, said he, work on. I then heard another noise in the machine, which appeared to be the effect of a rope breaking. This fresh admonition made me examine attentively the interior of our habitation. I saw that the part of the machine which was turned toward the south was full of round holes, several of which were of a considerable size. I then said, We must descend. Why? Look, I said, and at the same time I took the sponge and easily extinguished the fire which was round a few of the holes that I could reach; but, leaning on the lower part of the linen to observe whether it adhered firmly to the surrounding circle, I found that the linen was easily separated from it, on which I repeated that it was necessary to descend. He looked below and said to me, We are over Paris. Never mind that, said I, but let us see: is there no danger for you? Are you secure? He said, Yes. I examined my side and found that there was no danger to be apprehended. Further, I wetted with the sponge those cords that were within my reach. They all held firm except two, which gave way. I then said, We must pass over Paris. In doing this we approached the tops of the houses very sensibly; we increased the fire and rose with the greatest ease. I looked below me and perfectly discovered the Mission Étrangère. It seemed to me as if we were going toward Sulpice, which I could perceive through the aperture of our machine. On rising, a current of air made us leave this direction, and carried us toward the south. I saw on my left a sort of forest, which I took to be the Luxembourg; we passed over the Boulevard, and I then said, Let us now descend. The fire was nearly extinguished, but the intrepid M. Pilâtre, who never loses his presence of mind and who went forward, imagining that we were going against the mills that are between the little Gentilly and the Boulevard, admonished me. I threw a bundle of straw on the fire, and, shaking it in order to inflame it more easily, we arose, and a new current carried us a little towards our left. M. Rozier said again, Take care of the mills! But, as I was

looking through the aperture of the machine, I could observe more accurately that we could not meet with them, and said, We are arrived. The moment we touched the ground I raised myself up in the gallery and perceived the upper part of the machine to press very gently upon my head. I pushed it back and jumped out of the gallery, and on turning myself toward the machine expected to find it distended, but was surprised to find it perfectly emptied and quite flattened.

So ended the first human aerial voyage that history definitely records. It was swiftly and unexpectedly duplicated. In the new United States of America, and before there was any possibility that the news of De Rozier's success could have reached them, two men in Philadelphia achieved free flight in a hydrogen balloon. Fame can never catch up to them now, but at least they deserve a respectful salute.

The Messrs. Rittenhouse and Hopkinson, of the Philosophical Society of Philadelphia, are the unsung Americans. They achieved flight (or, more accurately, they helped Mr. James Wilcox, carpenter, achieve flight) on December 28, 1783. It had been only thirty-seven days earlier that the European attempt had met with success, and the slow communication of that day makes it improbable that anyone in Philadelphia could have known by then what had been going on in Paris.

Rittenhouse and Hopkinson had made many experiments with the lifting power of hydrogen. When it came to constructing a man-lifting aerostat they hesitated to put all their hydrogen into one bag — perhaps so that no one leak could cause collapse. Thus it was that when the brave carpenter Wilcox, after he had seen a number of captive balloon experiments proceed to his liking and had been cajoled with silver,

finally consented to go up, it was in a car to which were attached forty-seven small hydrogen balloons. This combination had a smaller lifting power than the same amount of hydrogen would have produced in one bag; but it was enough to lift Wilcox and preserve his sense of security. That is, it preserved it for ten minutes. Then Wilcox saw himself drifting helplessly toward the Schuylkill River. Had he kept his courage, he might have crossed it without harm, and brought civilization to West Philadelphia. But he did not. In desperate haste he cut open his balloons one by one until his car fell and spilled him in a roadway, dislocating his wrist. But, for all this ignominious conclusion, Wilcox the carpenter remains a real, if almost unknown, hero of the air.

IV

THE GREAT DECADE

In November 1783, inspired by the example of Pilâtre de Rozier, Professor Charles set about the construction of an inflammable air balloon which would carry passengers. His design has survived to this day with remarkably little modification. It included the now familiar network laid over a silken, rubber-varnished bag, with a valve at the top to control buoyancy.

The first man-carrying hydrogen balloon weighed about 150 pounds. It was, you see, considerably lighter and more compact than a hot-air balloon had been or could be. This new machine was finished speedily, and with comparative ease, although Professor Charles was always being dogged by hard luck which seemed to leave Joseph Montgolfier mercifully free. This time he had learned the secret of collecting hydrogen over water, with the result that promptly on the planned-for day, in December 1783, he had the first hydrogen balloon prepared for passengers.

On one count, at any rate, Professor Charles seems to have bested Joseph Montgolfier; he was the first inventor to trust himself in his own craft. With one of the Robert brothers, he ascended from the Tuileries a few weeks after the successful construction of the newest hydrogen balloon. Here was a voyage that was something more than a spectacle for crowds to watch and cheer. It was a careful scientific experiment.

Professor Charles carried thermometers, barometers, and other "philosophical instruments" and read them all constantly. The voyage, he said, was "delicious." It took him north-northwest across the Seine and landed him, an hour and three quarters later, in the little town of Nesle, twenty-seven miles from Paris. He and his craft were shortly overtaken by the fascinated Dukes of Chartres and of Fitz-James, who had followed him on horse and who signed a "certificate of descent" with great flourishes.

In spite of the descent, a good quantity of inflammable air remained in the balloon and Professor Charles's thirst for aerial voyaging was not yet slaked. So his companion, M. Robert, obligingly left the car, and the relief of his weight was more than ample to permit another ascent for the Professor. The peasants of Nesle let go of the car, "and I sprang up," says he, "like a bird. . . . In order to observe the barometer and thermometer, placed at the end of the car, without altering the centre of gravity, I knelt down in the middle, stretching forward my body and one leg, holding my watch and paper in my left hand, and my pen and the string of the valve in my right. . . . For myself, though exposed to the open air, I passed in ten minutes from the warmth of spring to the cold of winter. . . . I rose in the middle of the car to contemplate the scene about me. At my setting out, the sun was set on the valleys; he soon rose for me alone, who was the only luminous body in the horizon, and all the rest of nature in shade; he, however, presently disappeared, and I had the pleasure of seeing him set twice on the same day."

And Professor Charles concluded his account with a rapt description of the glory, beauties, and safety of aerostation. Particularly the safety. Happily, and very peculiarly, no

one had yet been killed or even injured in these early experiments. We know now that these early flights were attended by frightful hazards — few professional fliers would be brave enough to-day to ascend in replicas of these early balloons. There has seldom been a more blissful ignorance than that which enveloped early aeronauts. Some months later the gallant Pilâtre de Rozier was destined to lose his life in an attempt which seems now like incredible foolhardiness, and there was to be a marked slacking off in the raptures over the safety and beauty of the new means of travel. But this was in the future. The naïve happiness of inventors and travelers who had finally laid the proud force of gravity in the dust knew nothing of it.

A slight foreshadowing of disaster came in England, where no one had yet ascended, but where the game of the hour was to build and launch miniature hydrogen balloons. One of these was found by two men in Staffordshire, who took it home and began to experiment with it in a candle-lit room. The indignant balloon promptly blew up with a noise much louder than any cannon of the day, wrecked the house, and almost killed four people. Hydrogen and oxygen produce, weight for weight, the most violently explosive combination that science yet knows of. The happy eighteenth century did not know this sharply realistic fact.

By now aeronauts had come to realize how helpless the balloon was. It was without any will of its own. The wind blew whither it listed; the balloon could only go along. But, in addition, aeronauts had only a partial control of altitude. If the balloon sank too low, they threw out ballast. The balloon would then rise too high and it would be necessary to valve it of hydrogen. It would then sink too low

again. This would continue until all of the ballast and most of the hydrogen had been scattered to the winds. Then, wherever he was, the aeronaut came down. He had no choice.

The brothers Robert, in July 1784, shrewdly undertook the construction of a new type of balloon — one in which they hoped altitude could be better controlled and maintained. Inside the main hydrogen sac was a smaller balloon which could be, by means of a bellows, filled with ordinary air. Here was the forebear of which the modern ballonet is a descendant. The theory was quite correct and the brothers Robert had taken it from General Meusnier, the brilliant army engineer who had suggested it and many another aeronautical improvement far in advance of his time. If air were forced into the interior of the balloon, the total weight of the aerostat would increase and tend to check ascent. If air were released, weight would decrease and the balloon would rise. In this way the brothers hoped to avoid these alternate expenditures of sand and hydrogen. The brothers Robert aimed at control of direction, too, and carried five parasol oars with them for the purpose.

Unfortunately, when they went up on July 15, 1784, this new balloon did not distinguish itself. The cords which held the interior balloon in place gave way and the ballonet fell into the aperture of the hydrogen sac. Then, when the aerostat finally rose above the clouds into the sunshine, the heat of the sun got in its warming work on the hydrogen, which could not escape, and therefore expanded the sac almost to bursting. Every attempt to poke the stubborn ballonet away from the opening was unsuccessful. The Duke of Chartres, a passenger, undertook heroic measures. He

punched two holes in the hydrogen envelope with the flagstaff which the balloon carried and tore open the fabric for a length of seven or eight feet. The balloon immediately descended at dangerous speed, but sixty pounds of ballast quickly cast overboard checked the descent enough to let the aeronauts out alive.

J. Tytler is an unsung celebrity. He was the editor of the second edition of the *Encyclopædia Brittanica,* but supplemented this sedentary occupation by a deep interest in aerostation. He was apparently the first man to rise from British soil. On August 25, and again on September 1, 1784, he succeeded in making two short flights at Edinburgh, Scotland, in a fire balloon which he himself had constructed. His enthusiasm and persistence did not win him, to the contradiction of the copybooks, much in the way of satisfactory achievement. He was able to do little more than rise from the ground. At least he was a man of accuracy, and unlike many experimenters, ancient and modern, he made no extravagant claims for his performance. In spite of the more spectacular accomplishments of his French predecessors he kept his imagination well in check and reported only "leaps," not "ascensions," in his fire balloon.

Much celebrated, on the other hand, was young Vincent Lunardi, who almost always receives a great part of the credit due to Mr. Tytler. It is not difficult to see why. Young Lunardi was a handsome and dashing Italian, highly popular, well connected (he was secretary, at one time, to the Neapolitan Ambassador), and by all accounts not slow to dramatize himself and his accomplishments. No wonder he obscured the conscientious Mr. Tytler, a musty man of letters

Lunardi lived in an age of demon letter writers, and lived up to it well. His own accounts of what he called the first aerial voyage in England and of his five later voyages in Scotland are still preserved in the form of a series of letters to his guardian, the Chevalier Compagni. Lunardi chose " inflammable rather than elastic " air for his balloon. He cared little for the idea of a Montgolfière, he said, by reason of the fire it carried, since " the least error in the application may be the occasion of consuming the apparatus." In other and simpler words, " it might take fire."

Lunardi had a few severe disappointments. He experienced, he said, the extremes of " rapture and dejection " just as one experiences the extremes of heat and cold. From Sir George Howard he had obtained permission to make an ascension from Chelsea Hospital. There then appeared on the same scene a Frenchman by the name of De Moret. Here was a hated rival, with a balloon which he announced would ascend on August 11 — a day earlier than Lunardi had planned for.

But De Moret did not make good his promise. Between fifty and sixty thousand people gathered on the grounds and waited for three hours to watch the aerostat rise. It remained only a vast, flabby, pulsing mushroom on the ground. Three hours exhausted the mob patience. Crowds dashed in and worked their anger off by doing heavy damage to all property, real and personal, that could be found close by. De Moret was referred to vocally and in print as the Chelsea Bum.

Sir George Howard and his advisers swiftly met together and revoked Lunardi's permit on the suspicion that he, too, was a foreign impostor. Lunardi was in despair and wrote

a number of letters to his guardian setting forth his unhappiness at great length.

Finally the skies cleared. "What the philosophers dare not attempt, the ladies easily accomplish." And Lunardi, being young and handsome, found that it had been easily accomplished that he should have permission to rise from the Royal Artillery Grounds. On September 15, 1784, he made himself ready once again before a huge throng which was this time graced by His Royal Highness the Prince of Wales — he who later became His Majesty William IV.

The English crowds which watched these experiments seem to have been much more critical and impatient than the French. As Lunardi was forced to postpone his ascent from hour to hour because of the slow rate at which the balloon filled, the watchers came closer and closer to the end of their patience. It seemed likely that they would explode all over again into some sort of violent hostility. George Biggin, who was to have been Lunardi's companion, then generously offered to remain behind and thus shorten the time which the balloon would require to gather enough lifting power. So Lunardi bade him good-bye, climbed into the gallery, and sailed away, accompanied by a cat, a dog, and a pigeon. He seems also to have been accompanied by an ambitious dinner, for he made a meal of wine and chicken while aloft, and later tells of the quantity of silverware he cast overboard when he was in danger of too quick a descent. Likewise he must have had a good deal of writing paper, some ink, and a few well-sharpened quills; for he settled down to correspondence and wrote several letters during his passage. For about two hours he traveled, wined, dined, and wrote. Then he came down at South Mimms and landed the cat, which was perish-

ing from the cold. (The cats of those days do not seem to have been appreciative of the boon that science was conferring on them. History records a number of feline deaths from cold or exhaustion, although no other animal seems to have minded at all.) This humanitarian act accomplished, Lunardi resumed his voyage.

He was quite sure that some sort of wings, or, as he called them, oars, could be used to guide balloons in their flights. His own was equipped with them on this journey and he retailed an elaborate story of his successful use of them. Yet there is every reason to think that young Vincent was not strictly accurate. He may honestly have believed that he was making progress, but in the light of present science we know it is quite impossible that any of his efforts could have been sufficient to persuade his balloon to go anywhere it did not want to go.

As a matter of fact, Lunardi very soon dropped one of his oars. Some swooning young lady saw it fall and thought that it was Vincent. She languished and expired a few days later. At least, this is the hero's story, and he tells it with gravity and concern. He regrets, he says, that anxiety over his life cost another one, but he finds a consoling thought. A judge was presiding over the trial of a criminal in London as Lunardi passed over the courthouse. The judge and jury rushed to see the balloon and returned so transfigured and ennobled that they promptly released the prisoner with urgings to a better life. That, says Lunardi, balanced things up.

Lunardi's popularity with ladies seems to have involved him in at least one aeronautical complication. To him Mrs. L. A. Sage owes the fact that she was the first Englishwoman to go up in a balloon. She tells about it in a letter addressed

to a " female friend." " All is now over," she says, " and I find myself more happy and infinitely better pleased with my excursion than I ever was at any former event of my life."

Mrs. Sage made her historic ascent on June 29, 1785, from St. George's Field, London, in the company of George Biggin. During the progress of the balloon's inflation she remained discreetly in a coach near by in order to escape those remarks which " she knew would naturally be made." This cryptic phrase becomes clear when you realize that Mrs. Sage, reduced to her lowest common denominator for aerostatic purposes, weighed 200 pounds.

The original plan called for five passengers in the carriage. The balloon refused. Since there seemed nothing to do about Mrs. Sage, three passengers left the car, and Mr. Biggin and Mrs. Sage went up together. " I never was more mistress of my reason," she insists, in rebutting the gossips' story that she fainted. Her own explanation is that she knelt down to repair some lacing of the gallery and thus went into a temporary eclipse.

For all this attitude of helpfulness, Mr. Biggin probably felt less than love for her. He had hoped to make this a highly scientific voyage, and the first thing his 200-pound lady passenger did was to kneel on the barometer. He could probably have killed her then and there, but he seems to have controlled himself sufficiently to lunch with her shortly after in the car, on ham and chicken, lightened by a glass of Florence wine. The empty bottle, with the sublime carelessness of the age, they flung overboard into a London street.

Mr. Biggin sounded a small bell, to observe whether its pitch might be different in more rarefied air. It was not. Then he rubbed a stick of sealing wax over his coat and with

it charged the pith balls of an electroscope. They separated. Then he held the electroscope out toward a passing cloud and noted that the balls diverged even further. From this Mr. Biggin quite correctly deduced that the electrical charge on the cloud was negative.

The scientific details of the voyage having been settled so far as possible without a barometer, Mr. Biggin and Mrs. Sage descended, and Mrs. Sage alighted in a field of beans with the assistance of some half-dozen onlookers. Lightened by 200 pounds, the balloon was again capable of ascension, but Mrs. Sage had somehow managed to damage the bean crop to an extent which so infuriated the farmer that he prevented any further experiments. The balloon narrowly escaped destruction and was eventually brought back to the city by cart.

During the course of 1785, Lunardi made a number of flights. The record of five of them in Scotland he likewise preserved by letters to his guardian. In one such flight he came close to losing his romantic young life. Just before Christmas he rose from Heriot's garden at Edinburgh, disregarding the advice of the governor of the castle, who cautioned that the direction of the wind was sure to carry him out to sea. But Lunardi, seeing his audience inclined to doubt his courage, cast off, saluted them, and sailed away. Half an hour later he found himself traveling northeast over the North Sea. He sighted a boat rowing toward Musselburgh. He was a generous soul, if slightly heedless, and immediately flung overboard half a pound of cake. This was not a missile, but a gift. Unhappily, Lunardi himself was not able to see whether the oarsmen or the fishes were the beneficiaries.

Later, the wind shifted to due west and he attempted to

land on the point of Archerfield. Unfortunately he missed it and found himself again above the sea. He was in real trouble, but his first thought was not for his life, but for the safety of the uniform of the Scots Royal Archers which he wore. He took it off and fastened it to the upper hoop of the gallery to save it from the sea.

Within an hour after his ascent, the basket of Lunardi's balloon was tipping the wave crests and spray was spotting his uniform. He looked about for help. All he could see was three ships just distinguishable toward the Isle of May. With the water up to his waist, he suddenly saw a black spot making toward him. It was a small boat with all sail set and the oars manned — a fishing craft. Lunardi threw the fishermen a rope and asked that the balloon be made fast. This idea did not seem to appeal to the crew. No sooner had Lunardi stepped aboard than they cast it off and, still carrying the uniform of a Scots Royal Archer, it disappeared into the heavens. Lunardi, cold and none too nattily dressed for one who was, after all, a secretary to the Neapolitan Ambassador, sat down sadly upon a mound of slimy fish.

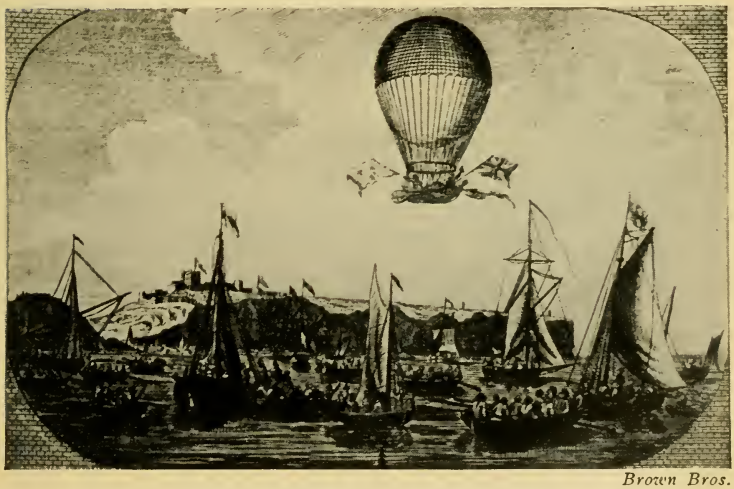
History now forces us to retrace our steps slightly in pursuit of the accomplishments of a few less vivid aeronauts — in particular, Jean-Pierre François Blanchard.

Blanchard was a native of Andelys, a village in Normandy. All his life long he was a fervent believer in the possibilities of aviation. His very first attempt to construct a heavier-than-air flying chariot showed the extent of his ambitions. It was two hundred square feet in area and had four wings. Blanchard built it near Paris in 1781, but never permitted the public to see it, probably because he had been unable, in the privacy

Vail Collection

PROFESSOR CHARLES GOES VOYAGING

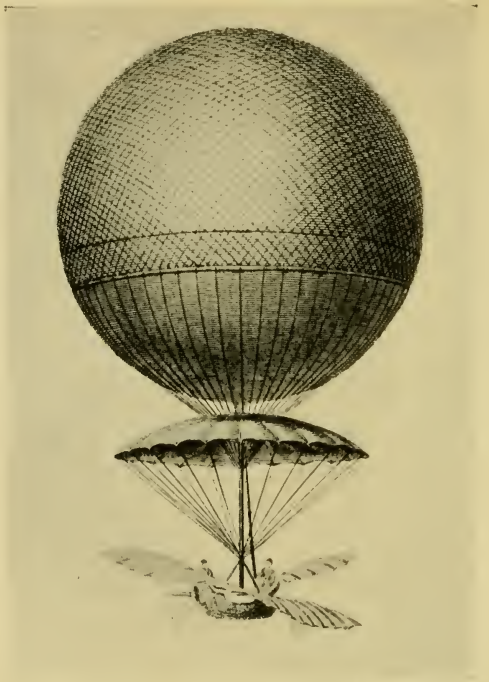
His Second Ascent from Nesle (*Page 33*)



Brown Bros.

FROM SHAKESPEARE CLIFF

The Departure of Blanchard and Jeffries from Dover on Their Flight Across the English Channel (*Page 45*)



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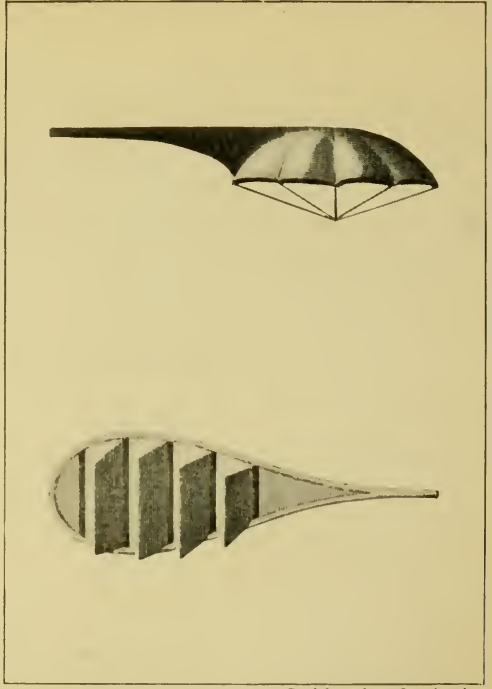
BLANCHARD'S BALLOON

The First Aerial Ship to Cross the English Channel (*Page 44*)



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OARS AND WINGS

Means by Which Blanchard and Lunardi, Early Aeronauts, Hoped to Control the Direction of Their Craft (*Page 44*)

of what has been translated as his "back yard" to make his apparatus fly. He found it impossible to make the wings beat fast enough to produce useful results.

Blanchard remained undiscouraged. He built a second machine, which was launched in that same year from one of the towers of Notre Dame on the Île de la Cité in Paris. This one carried freight in the form of a criminal, who had been offered the promise of a pardon if he should manage to survive the descent. He won his freedom, and Blanchard won much applause.

Despite this modest success with craft heavier than air, Blanchard dropped his experiments completely once the success of lighter-than-air flight seemed assured. Thereafter he became known principally as an aeronaut — always a brave and resourceful one. He gave much thought to the problem of directing the passage of balloons, and he seems to have been one of the first inventors of the parachute. His first aerial flight in England was made on October 16, 1784, in the company of Professor Sheldon of the Royal Academy. Six weeks later, Blanchard made his fifth voyage — one that is notable because it marked the beginning of his association with Dr. Jeffries, a Boston physician who was America's first aeronautical hero, if we except the carpenter Wilcox.

In his enthusiasm for flight, Dr. Jeffries was the Lindbergh of his day. Flying fascinated him and there was no chance he would not take, no arrangement he would not agree to, if only he might fly. He bears the proud distinction of being the first passenger to cross the English Channel by air. The aeronaut in charge was Blanchard, but the arranger, the financial backer, and in many ways the true hero, was Jeffries.

Blanchard drove a rather hard bargain with him. Jeffries

organized the flight, contributed all the money he could, and raised a bit more; he placed all the technical details in Blanchard's hands, with authority to proceed as he best saw fit. Notwithstanding this generosity, Blanchard and Jeffries quarreled several times; and Jeffries, a few days before the flight from Dover to France, agreed that if it were necessary to save the balloon from any accident in crossing he would "get out of the car." Since getting out of the car would mean very little save a voluntary resignation to drowning in order to save his companion's life, it does seem that Dr. Jeffries was not ungenerous.

The balloon which the travelers planned to use was the same one that Blanchard had constructed in March of that year, and in which he had made all his subsequent flights. It was a hydrogen balloon, twenty-seven feet in diameter, with a boat suspended below after the manner of Charles and Robert. But Blanchard had, in pursuit of his dream of guiding aeronautical flight, added two wings to be worked by the passengers, a rudder, and, best of all, a large umbrella spread between the gas bag and the boat, on the theory that, if the bag burst, the umbrella would check the fall. This was an early attempt at the construction of a practical parachute.

Jeffries and Blanchard left London on December 17, 1784, for Dover, taking with them the balloon and boat. Repairs and adjustment to the balloon, followed later by a number of stormy days, kept the two aeronauts under the chafing restraint for several weeks. It was then that the quarreling broke out. Dr. Jeffries had enemies anxious to discredit him. He complains that someone sought "secretly to increase the weight of M. Blanchard by loading him with a concealed heavy girdle" — although the reason for any such attempt

is not easy to see at this far distance from the eighteenth century. The countrymen of Blanchard seem likewise to have been busy stirring up rumors to the effect that the doctor proposed to abandon his companion and force him to undertake the voyage by himself. Dr. Jeffries came close to weeping at that, for he had sworn all sorts of oaths that if anything prevented Blanchard from making the flight he, Jeffries, would go alone — aeronaut or no aeronaut. Mysterious rumors reached the governor of Dover Castle also, who thereupon called on Dr. Jeffries and asked for reassurances. Apparently he got them, for the attitude of the townsfolk changed markedly thereafter and there came a time later on when the corporation of Dover made this Boston physician an honorary citizen of the town.

The flight itself was an exciting adventure. On January 7, 1785, the wind prevailed in the right direction and Jeffries and Blanchard hopped off, from the selfsame cliffs that Shakespeare celebrated in *King Lear*. "We rose slowly and majestically," says Dr. Jeffries ("majestically" being the favorite way of describing all ascents), "having in the car with us three sacks of sand ballast, a large parcel of pamphlets, two cork jackets, a few extra clothes of M. Blanchard, a number of inflated bladders, and two small anchors." The usual crowd of curious onlookers, which every aeronaut of those days referred to as a "vast concourse," was there to wave good-bye.

All went well for the first hour. The day was fine, the wind a steady north-northwest. Passing vessels saluted the aeronauts with their colors. Dr. Jeffries has much to say on the enchanting view of England and France from the air. The balloon rose to an altitude of about nineteen hundred

feet and, under the decreased pressure, began to distend dangerously. Dr. Jeffries untied the entrance sacs at the bottom to allow the excess of hydrogen to push its way out.

But apparently the aeronauts, lost to wonder in the alternate views of France and England which the slowly revolving car gave them, were careless, and did not notice how much hydrogen had escaped or how rapidly they were descending. By two o'clock they were no more than one third of the way across. Then began a grim and courageous battle. The three sacks of ballast went overboard; then most of the pamphlets with which Dr. Jeffries seems to have hoped to bring enlightenment to France. For fifteen minutes this sufficed. Then the rest of the pamphlets had to follow. Slowly the English Channel was enriched by biscuits, apples, the useless oars and wings, the rudder that did not steer, all " ornaments " inside and outside the car — even a bottle, although of what we do not know. Then came the anchors and cords, and bit by bit the clothing of the travelers; first an extra coat, then both remaining coats, then those last refuges of modesty — trousers. Aerodynamics was satisfied, and the balloon rose again, soon reaching such a height that the almost entirely unclad travelers suffered bitterly from the cold.

But in the suffering there was triumph. The balloon was now over the land of France, and by one last remarkable recourse Dr. Jeffries and M. Blanchard succeeded in landing in a tree. A monument to-day marks the spot, in the forest of Guines, not far from Ardres, where those brave aerial travelers landed. By coincidence it was almost on the spot where Henry VIII, King of England, and François I, King of France, held an interview, almost two hundred and seventy years before; the meeting on the Field of the Cloth of Gold.

V

FIRST DISASTER

Aerostation had now conquered its worlds — its tiny, unimaginative worlds. The English Channel had been crossed, and France and England had been joined together, to their mutual distaste. The first flight in Italy had been made by Il Cavaliere Don Paolo Andreani, and the two brothers Gerli. Ireland had had an aeronaut in the person of Crosbie, who had ascended in January of the year 1785 and had made an unsuccessful attempt to cross the Irish Channel. America had had its share of glory, although Europe neither knew nor cared. Such a dream as that of spanning the oceans was beyond the imagination of the eighteenth century, and aeronauts began to wonder what they might do next. It occurred to Pilâtre de Rozier that the English Channel had been crossed in one direction only; if he crossed it in the other, from France to England, he would establish another reason to the claim he already had for historical immortality. He resolved to try. The result was the first major catastrophe in aeronautics.

De Rozier had made up his mind to attempt the journey in a new type of craft — a combination of a hydrogen balloon and a Montgolfière. He reasoned that the usual expenditures of gas and ballast could be avoided if he added or subtracted buoyancy by regulating its fire. His theory was shrewd and entirely correct. Unfortunately he did not realize one fact: the amazing and vicious explosiveness of the gas hydrogen.

From the beginning De Rozier seems to have had a convincing premonition that his voyage would end in disaster. He told his friend M. Duriez, an apothecary of Boulogne, that if he could he would have given twenty thousand pounds never to have undertaken "a scheme so perilous to life and frame." But he was a gallant man; he had given his word and go back on it he would not. To friends who suggested that he abandon his voyage he said, "For God's sake don't mention such a thing; it is *now* too late; give me encouragement, for I would rather take a knife and pierce it to my heart than give up the attempt which I have engaged in although I was certain of meeting with death."

De Rozier was not merely attempting to copy the exploit of Blanchard and Jeffries. He began with his plans in December, a month before their successful flight. Once the balloon was constructed there was the usual expensive and nerve-racking wait for proper prevailing winds. Twice the balloon was filled with hydrogen and just as De Rozier was ready to make his attempt the wind changed. Many old mariners said that they had never remembered an eight-month period during which the wind blew so rarely from the proper quarter. It was not, therefore, until June 1785 that De Rozier was able to start his flight.

A week previous, De Rozier had made his will. On the evening before his ascent he spent two hours in his devotions at the church of the Cordeliers. He vowed that if ever he succeeded in reaching England safely he would have nothing further to do with aerostation.

To the pleadings of his friends, an English young lady named Dyer added her voice. She was comely and personable. If anyone could make successful persuasions it was she.

Yet listen to this testimony of a contemporary: "It is not the least extraordinary that De Rozier should be captivated with such a combination of good sense, beauty, and accomplishments as Miss Dyer so eminently possessed; but it is very extraordinary that he should have rejected all her tender remonstrances and given up the certain prospect of immediate happiness to embrace the most dangerous and presumptuous experiment that was ever attempted by man."

All the more glory belongs to the gallant De Rozier. Nothing much in the way of exploration, discovery, or the furthering of some new art has ever been accomplished except by men who, unlike more ordinary individuals, reject tender remonstrances and give up the certain prospect of immediate happiness to embrace dangerous and presumptuous experiments.

On the morning of Tuesday, June 14, the workmen assembled and began to fill the hydrogen balloon which was to be placed above the Montgolfière. The wind was favorable, the air was clear. Apparently, after more than six months, the day of ascent had arrived. And then in the midst of all preparations, as if it were giving one last warning, the wind changed again. No amount of determination could ever start the balloon toward England that day. The aeronauts would try again early the next morning. The workmen were ordered to return at ten o'clock that night, for the balloon had to be ready by dawn of the following day.

The hydrogen balloon of this queer and tragic combination was 33 French feet in diameter and weighed 300 pounds. The Montgolfière was 24 feet high and 12 feet in diameter and was suspended about five feet below the balloon. It was made of green unvarnished silk, lined with paper. The cir-

cular gallery hung below the Montgolfière; it was about 15 feet in diameter and woven of small osier twigs. Ballast, provisions, wood, straw, fagots, and charcoal were packed, that night, into the gallery.

Meanwhile M. Romaine, the manufacturer and owner of the aerostat, became engaged in a violent discussion with the Marquis de Maisonfort. Romaine claimed the privilege of making the voyage with Pilâtre de Rozier. But the Marquis wanted to go instead. More than that, he was willing to pay for the privilege. He shared none of De Rozier's doubts about the triumph of the voyage and he wanted to have a part in it. Days before he had offered a hundred louis d'or to Romaine for the privilege of substituting for him. It had been refused. Now he offered two hundred, and Romaine, balancing cash and glory, decided on the cash.

Of the three, only De Rozier was displeased at this change. He had no wish to see his young friend in a catastrophe. He argued violently and did insist that if the Marquis was to be his passenger he must immediately make his will and write a letter to a friend asking him, in case of accident, to break the news to his mother. These gloomy precautions had no effect on the spirits of the young Marquis. De Rozier went further. He gathered numbers of his friends together for group dissuasion. These, too, had no result. Finally, at ten o'clock on the night before departure, De Rozier and M. Romaine together called on the Marquis. They had, they said, pledged themselves to the public to make the trip together. It would be improper for them to make any alterations in the plan now. Grudgingly the Marquis yielded.

Thousands of people gathered as soon as the day was light, fearful that they might arrive too late. As always, there was

ample time. Poor De Rozier showed the strain of preparing for the voyage. He was the most experienced aeronaut in the world and he kept a firm hand on his courage, but he could not convince himself that things were going as they should. He walked about the gallery, himself tying every single cord which attached it to the Montgolfière. He watched the progress of inflation. By every device that experience had taught him he tested each part of his machine. At last he was satisfied. A little before seven o'clock the balloon filled and, under his direction, workmen moved it to the butchery at the top of the high street from which it was to ascend. Here he made a few final adjustments and begged that his friends conceal their tears.

De Rozier and the disappointed Marquis de Maisonfort embraced each other. Then the aeronaut and his triumphant passenger Romaine set themselves in the gallery. At twelve minutes past seven the starting cannon was fired and the aerostat rose straight into the air. At first it seemed only to gain altitude; a little later it reached a current of air which drove it to the west.

For thirty-two minutes nothing happened to justify the constant forebodings of Pilâtre de Rozier. But in the thirty-third, when the balloon had traveled only four miles from its starting point in Boulogne, the watchers on the ground saw a cloud of horridly majestic smoke, a soft tongue of flame, and heard a muffled explosion. The gallery sped toward the ground with the rags of the proud balloon fluttering above it, whistling in the air. After a drop of more than three thousand feet, the gallery struck on the rocks near the shore of the Channel, which De Rozier had not even succeeded in reaching.

Thousands of spectators ran in converging lines to the spot, a mile from the village of Weemille on the Calais road. From beneath the wreckage of the Montgolfière and its gallery they dragged two limp bodies. Both had been horribly injured. De Rozier was already dead. Romaine breathed three deep sighs, but never spoke again. The premonitions had come true.

This first aeronautical tragedy must certainly have been caused by the explosion of the hydrogen balloon, due to the fire in the Montgolfière. Other theories were advanced at the time, but none was so plausible.

Bravery has its inevitable uses, even when it seems to do nothing more than take life to no effect. The tragic deaths of De Rozier and Romaine pointed the way clearly to the dangers of aerostation which everyone up to this time had regarded with a curious lack of interest. The tragedy spelled the slow but inevitable doom of the Montgolfière as a means of flight. Thereafter men concentrated their attentions more and more upon the hydrogen balloon. Later they were to find that it, too, provided a desperately hazardous mode of travel. When that time was to come, once again their thoughts were to shift in the direction of an even greater practicality.

The bodies of Pilâtre de Rozier and M. Romaine were buried without ceremony in one grave in the churchyard at Weemille. Within a few hours of the firing of the starting cannon, the remains of these two brave men were covered with the earth they had hoped to vanquish. They had made history, which, for all its sombreness, had advanced one step further man's aspirations to be the conqueror of the skies.

VI

HEAVIER-THAN-AIR

The sudden and violent disaster to Pilâtre de Rozier was a sharp check to the mounting enthusiasms of aeronauts. It is true that André-Jacques Garnerin was sufficiently blasé ten years later to rise in a hydrogen balloon and set off fireworks from it; none the less the public at large had become convinced that "the steadyness of the aerostat whilst in the air, its gradual and gentle descent," had been a bit overpraised by Tiberius Cavallo. The record bears this out. The decade between 1780 and 1790 witnessed seventy-six ascensions. Then came the De Rozier disaster; in the decade between 1790 and 1800 only six times did aeronauts trust themselves to the machines the "steadyness" of which had been a matter of so much early remark. Men's thoughts began to shift back again to the type of flight of which Leonardo da Vinci had been one of the earliest exponents — that is to say, heavier-than-air flight, or *aviation* as opposed to *aerostation*.

As early as the latter part of the seventeenth century, Robert Hooke, the English mathematician, realized that human muscles were not strong enough to allow a man to fly regardless of what design of wings might be attached to them. He began to wonder about mechanical means of power. "I applied my mind," he says, "to contrive a way to make artificial muscles." Quite correctly, he tested his theories with a model

which seems to have had springs actuating flapping wings. The thing flew, and Hooke retains the enviable distinction of being the second man in history (Leonardo da Vinci was the first) to build even a model capable of heavier-than-air flight. But he was by no means satisfied and felt that he had been, as he expressed it, " frustrated of my expectations."

In 1608 (one year after the founding of the colony at Jamestown) the scientist Borelli was born in Naples. He had a mind of the most amazing originality, which came close to anticipating the theory of gravitation which Sir Isaac Newton eventually laid down. He studied bird flight, and had some sensible remarks to make also upon a problem which is of serious concern to airplane designers even to-day: namely, how planes may land at low speeds. He said: " Now the ways and means by which the speed is slackened at the flight are these. The bird spreads its wings and tail so that their concave surfaces are perpendicular to the direction of motion; in this way the spreading feathers, like a ship's sail, strike against the still air, check the speed, and in order that most of the impetus may be stopped, the wings are flapped quickly and strongly forward, inducing a contrary motion, so that the bird absolutely or very nearly stops." It has been only within recent years that airplanes of variable wing angles have been developed so that landing speeds may be checked upon exactly this same principle that Borelli was the first to record.

The flapping-wing idea refused to die. In 1783, more than one hundred years after the publication of Borelli's work, an English artist named Miller constructed a flying chariot built upon the model of a West Indian crow. What virtue this particular species of bird had in the eyes of the artist

Miller we do not know. The wings of the machine were driven by mechanical power, with motions in perfect imitation of nature. The operator turned a winch, and the winch drove a small wheel which in turn drove two others at the right and left, moving the wings. The aeronaut sat proudly at the winch and ground away. He gave his illustrious attention also to the "aerial helm," which guided a fine spreading tail that could be moved perpendicularly, horizontally, or obliquely. It never flew. In fact, it never had the remotest chance of flight, but Miller died before the crushing truth came home to him.

Still the idea of flapping-wing navigation flourished. It seems to have had a fatal fascination for artists. Thomas Walker, a portrait painter, was one of the next victims of the delusion. In 1814 he published an American edition of an elaborate treatise in which he gave full particulars of the machine he proposed to build. "There cannot remain a doubt of success," said he.

Like Borelli, Thomas Walker quite correctly stated that the pectoral or breast muscles of a man were entirely too weak to support him in the air; but Walker, not having the advantage of accurate computations on the relation of strength to body weight among birds and men, proposed to get around the oversights of the Creator by supplying the man with a car to sit in. Thus the whole weight of his body would be supported, he reasoned, and since he would assume an attitude similar to that struck in rowing, he would be able to exert his full bodily strength to propel himself by means of a lever.

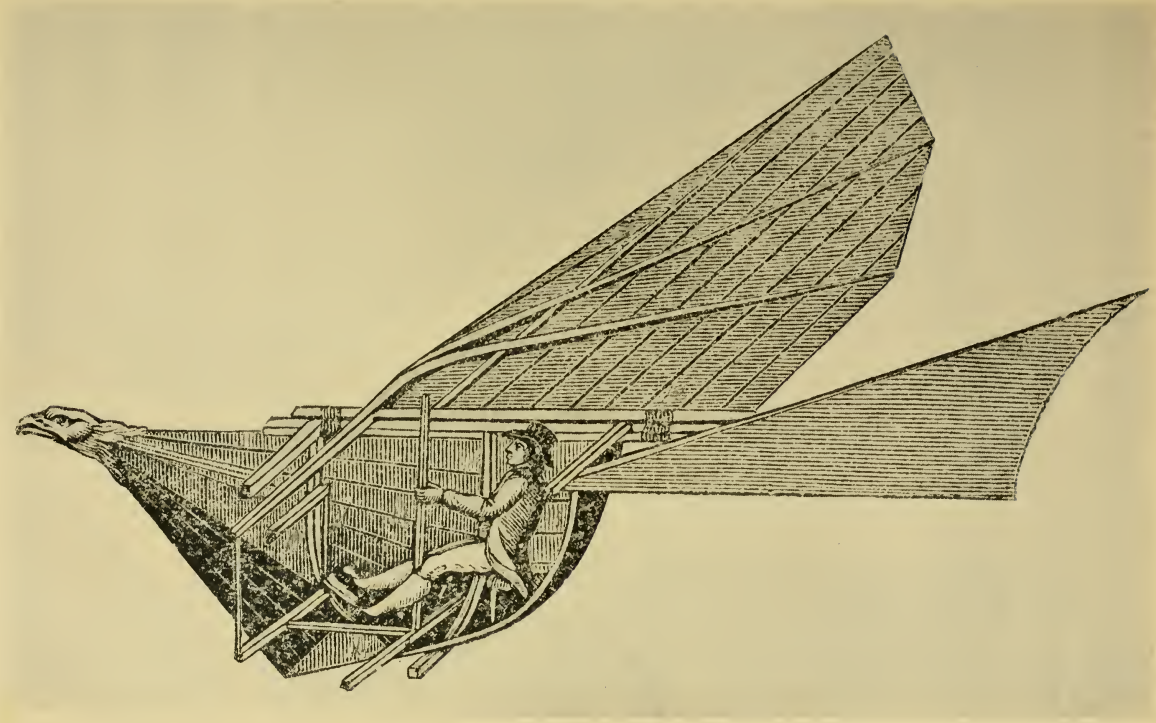
Walker had some statistics which comforted him. He showed that the American condor is 14,336 times as heavy as a humming bird and yet, in spite of this incredible dispropor-

tion of weight, it could, by the same mechanical use of its wings, stay aloft in the air with as much ease as the humming bird. And more than that, it had an ability which its frailer sister lacked. Condors had been known to fly off with sheep in their talons, and the combined weight of condor and sheep would certainly be 204,000 times the weight of a humming bird. A man with fifteen additional pounds of weight due to artificial wings would be only five times as heavy as the condor, and these statistics, Walker believed, furnished a water-tight proof of the soundness of his idea. He did some further calculating and concluded that the proper span for man's artificial wings was fourteen feet.

Later on he became even more coldly practical and said, " A coachmaker is accustomed to make strong work with little weight of materials. He, therefore, would be the most proper person to make a machine of this kind. The wings and tail should be made of silk, very compactly woven, and as impervious to air as possible. The silk which the wings are formed of should be laid on in separate broad slips and should open to admit the air to pass through as the wings move up and close together as they come down, in the same manner as I have described the action of the quill feathers in the wings of birds."

Walker admitted that his machine would not of itself take off from level ground. His alternative was the building of an inclined plane. The driver was to get into the car and pull his levers. The wings would then flap, the car would *climb* the plane, leap from the top, and soar away.

As an afterthought to the whole magnificent idea, Walker suggested that " one of Messrs. Mead & Co.'s new invented revolving steam engines " could be placed either in his ma-



WALKER'S FLYING CHARIOT

Illustrating a Portrait Painter's Imagination (*Page 56*)

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SIR GEORGE CAYLEY

The "Father of British Aeronautics" (*Page 58*)

chine or in the balloons which, thirty years after their invention, were still incapable of any purpose or direction in the air. Walker seems to have been unaware of the possibilities of the aerial screw, for the steam engine was not intended to drive a propeller, but to drive flapping wings with which the balloon would be equipped. And a large tail with a universal joint would supply perfect steerage. Then at last, thought Walker, the problem of aerial navigation would be solved and balloons would be able "to convey a number of passengers to any place of destination with accuracy and safety."

Not quite so, Thomas Walker. Mr. Mead's patent steam engine was a fine affair in the year 1814, but it developed only one horsepower for each eight stone of its weight; that is, the equivalent of one horsepower to every 112 pounds. The first practical engine which ever brought about a power flight with a full-sized plane developed a horsepower for every fifteen pounds, and to-day airplane-engine designers are able to pack the theoretical power of one horse into the weight and volume of a box of candy — two pounds, or less. Thomas Walker in 1814 was in many ways farther from the truth than Leonardo da Vinci in 1505. Yet he had the vision to think of air mail, and to realize the value of flight to exploration. And this seemed most important to him: "It [flying] may tend greatly to reduce the vast number of horses kept in this kingdom, and by that means a *very great quantity* of land, which is taken up at present in growing hay, oats, and beans for the support of these quadrupeds, might be then cultivated for the increase of our national stock of subsistence for the population."

While this wild portrait painter was dreaming his vivid dreams in England, a true scientist, often called the "father of

British aeronautics," was also at work upon problems very similar. He was Sir George Cayley, who developed small flying models of complete and successful practicality.

Cayley was born at Brompton, England, two days after Christmas in the year 1773. Accordingly he was ten years old when the thrilling news of the Montgolfier discovery was made known to the world. It took an immediate and violent hold on his imagination. He never shook it off. Indeed his whole life was given over to thoughts and experiments on flight by means both lighter and heavier than air.

"An uninterrupted navigable ocean that comes to the threshold of every man's door ought not to be neglected as a source of human gratification and advantage," he once wrote. His persistence in studying this new ocean and devising craft to sail it did more toward persuading men to consider the problems of air flight sanely and sensibly than did, perhaps, the contributions of any other one man.

Cayley made his first aeronautic experiments at the modest age of twenty-two in 1796. It was he who developed Leonardo da Vinci's aerial screw to something approaching a useful purpose. He did it by studying and improving on the Chinese or aerial tops which he, like the Wright brothers of later fame, had played with as a boy.

The modern equivalent of the aerial top may be purchased in any five and ten cent store. Cayley's tops consisted of a two-bladed propeller, made out of goose quills and fastened at the centre to two strings which he wound tightly together. When the strings were pulled they began to unwind, the quill screw spun swiftly and rose straight into the air — a perfect helicopter. Cayley went triumphantly on with his experiments, varying his design as new ideas occurred

to him. Before he gave up he had succeeded in building a model which would rise ninety feet.

Having demonstrated the practicality of the aerial screw, Cayley went on to further experiments in conquering the "uninterrupted navigable ocean." He began experiments with gliders, and ridiculed the flapping-wing idea which had obsessed men's minds for centuries. More than a hundred years earlier Besnier had apparently built and flown a glider without knowing how or why. Now Cayley set out "to make a surface support a given weight by the application of power to the resistance of air." He was swiftly successful. His glider designs make him indisputably the first true inventor of the airplane structure as we know it to-day.

Cayley made his gliding experiments on a large scale. His first machine had a wing surface of 300 square feet — large, even now, when compared with the 485 square feet of a modern Ford passenger-carrying plane. He launched his first glider from the hill behind his ancestral estate, called Brompton Hall, and he was thrilled and gratified to watch it make a graceful, gradual descent. He was quite understandably excited. "It was beautiful to see this noble white bird sailing majestically from the top of a hill to any given point of the plain below it with perfect steadiness and safety, according to the set of its rudders, merely by its own weight descending at an angle of about eighteen degrees with the horizontal."

The rudders to which Cayley referred were both horizontal and vertical, which gave him the enviable distinction of being the first man to devise any such system of control.

And Cayley (who was by now Sir George) made this further fascinating discovery: when he ran forward against the wind with the glider he would now and again be lifted

slightly off the ground and carried for several yards. Sir George saw clearly then that he was hot on the track of a practical machine to navigate the ocean that came to every man's door. He built another and larger model with accommodations for an aeronaut.

For aeronaut he nominated his coachman. The coachman was none too enthusiastic over this honor, and demurred. Sir George gently insisted. The coachman continued to demur. This process went on for some time until Sir George was finally the victor. The coachman clambered aboard. Encouraged by Sir George, he ran wildly down the hill, carrying the glider with him until a gust of wind caught it and whirled it into the air. The coachman thus became the first aeronaut who had ever taken off from the ground and risen in a heavier-than-air machine. Another epoch in aviation was marked that instant.

The coachman, however, was in a poor position and frame of mind to think about matters of immortality or historical perspective. He was busy only with trying to maintain his balance and stability in this confounded contraption of bamboo and linen, most unlike a sturdy and well-built coach. None the less, he flew nearly 900 feet across a little valley.

Most of the inventors of the day were too busy contriving means of getting into the air to consider the even more important matter of getting safely back to earth. Not until he saw his coachman reach the summit of his flight did it occur to Sir George that he had given no particular attention to this phase of flight. A few seconds later the glider and the coachman came down with a prodigious, splintering crash. Sir George rushed to the wreck of his proud machine, from which the coachman, by some chance unhurt, was disentang-

ling himself with a strange mixture of haste and dignity. He cleared himself of the last fragments of the glider, stood up, and faced his employer.

"Please, Sir George," he said, "I wish to give notice. I was hired to drive, not to fly." So Sir George found another coachman and continued his experiments.

Cayley was a man of amazing vigor and imagination. His next thoughts were directed toward adding an aerial screw to the glider and applying power to the screw. He wasted no time over the steam engine which had beguiled Thomas Walker and others. It was, he knew, too heavy. Instead, he showed himself a true prophet of the future by suggesting that the internal-explosion engine, only a little while before designed by William Chapman of Newcastle, might be a far more sensible power source. This showed real vision, for Chapman's engine was a barbarous and spluttering affair, the asthma of which you will swiftly forgive when you know that its fuel was a mixture of oil and tar. Sir George designed an engine of his own with which he hoped to apply power to one of his gliders, but one accident after another barred his way and he never accomplished his dream. Even though he failed, he knew what he was doing, and had the rare good sense to say that a horsepower developed by not more than two pounds of engine weight was "the *sine qua non* of the case."

It was from the brain of this extraordinary man that the first design for a biplane sprang. He spoke of "the great principle for producing strength without accumulating weight" and met it with a design of wings placed one above the other with diagonal bracing for strength. He saw the necessity, too, for stream-line construction and said, "Every

pound of direct resistance that is done away with will support thirty pounds of additional weight without any additional power."

Then, in 1816, having devised his flying top, flown the first man-carrying glider, invented the biplane, and brought a great breath of fresh air into musty and mistaken discussions about the application of power to flight, Sir George Cayley turned to balloons. It was impossible for him to think for even a short time of anything without somehow improving it. And so he improved upon the *dirigible* balloon, first suggested by General Meusnier, the gifted French Army engineer to whom aerostation owes so much.

There are few men in the history of flight who are partisans of both lighter- and heavier-than-air machines. Despite his early enthusiasm and amazing achievements with gliders, Sir George became a violent enthusiast for aerostation. He realized what we still believe to be quite true; that lighter-than-air craft offer greater facilities for the transportation of men and goods through the air for long distances than do mechanical means alone. Sir George, like everyone else, minimized the structural difficulties that lay in the way of dirigible design and have made the progress of aerostation so much slower than that of aviation. None the less, he set to work with his usual clear head.

He saw two things immediately. The stream-line principle must be applied to balloons. They must be elongated, since a sausage shape would offer less resistance to the air than would a sphere. And they must be of large dimensions if they were to become practical carriers. He established still another principle in use to-day: subdivision of the balloon into separate gas envelopes, all contained in one sheath,

instead of one bag in which a single rip or puncture might produce a fatal accident.

Cayley made two designs for a dirigible. The first was to be 300 feet long, 45 feet high, and 90 feet in maximum width. It was to have steam-engine drive, carry a crew of seven, and reach the dizzy speed of 15 miles per hour. The second, designed after more than twenty years of studying balloons, was to be 432 feet long, was to carry a steam engine and boiler, and be driven by two five-bladed propellers. Its cruising radius, he believed, would be 960 miles, and its useful load would be 34 tons. Only in this last figure do Sir George's feet seem to have strayed from the strict path of sensible scientific calculation. A century later the useful load of the Los Angeles is only 30 tons.

His dirigible designs suffered the fate that ideas always do when they are in advance of their times. They were never transferred from paper to substance. But when, in 1857, their designer died, he left behind him a world in which men's thoughts of flight had been radically altered by his unceasingly restless and unfailingly accurate mind. His suggestion of power for gliders, first considered an insane idea, had finally gripped men's minds; his labors with balloons had made a dignified craft out of the adjunct to a circus. Heaven knows where the world of aviation would be to-day if Sir George Cayley had not set the faltering footsteps of the nineteenth century firmly upon the proper path.

VII

THE MONOPLANE IDEA

The men who took up the torch that fell when Sir George Cayley died were two: William Samuel Henson and John Stringfellow.

More than twenty years after Sir George Cayley had given up his experiments with heavier-than-air craft to devote himself to dirigibles and the application of power and direction to balloons, William Henson began experiments with model gliders. They flew. Henson resolved to continue the study of the problems that Cayley had abandoned. He would apply power to gliding.

This man, quite justly known as the originator of the monoplane, lived a peculiar and obscure life. After a few brief years of fame which turned shortly into sour notoriety, he vanished. Yet Henson was a genius — aviation owes almost as much to him as it does to Sir George Cayley. He groped his way into close grips with truth only to blunder and let it slip from his grasp. His planes, full size and model, had many essential elements of the modern plane. He adopted the Fink truss for wing construction (he may even have originated it before Albert Fink, by whose name it is called); his design went so far as to include main and secondary ribs in the wings. He missed only one truth that Sir George Cayley had grasped — that a curved wing section was superior to a flat one. Without question he would have

come to this, and had the chemists, the metallurgists, and the mechanical engineers of the day only kept pace with him by designing an engine sufficiently light, there is much reason to believe that man-carrying flight under power would have been achieved by 1842.

Henson had begun two years earlier with experiments on gliders, but he found nothing for a power source which would even remotely serve him. The steam engine was having a slow and clumsy development at the hands of the successors to Thomas Newcomen and James Watt. Henson tossed aside their offerings and began building his own model engines. He constructed one engine which, with its boiler, weighed only ten pounds; installed it in one of his miniature planes, and hopefully launched it. It fell like a stone. If the engine builders of his day could not make a large machine of necessary efficiency to sustain flight, Henson had small chance with his smaller one: it is quite impossible to build a small engine which will weigh as little per horsepower as a large one.

Shortly afterward, Henson met John Stringfellow, a one-time lace maker, and in 1842 they formed the Aerial Transit Company, bringing into partnership also D. E. Columbine, who was the attorney and promoter, and Frederick Marriott, a journalist, whose function seems to have been that of press agent.

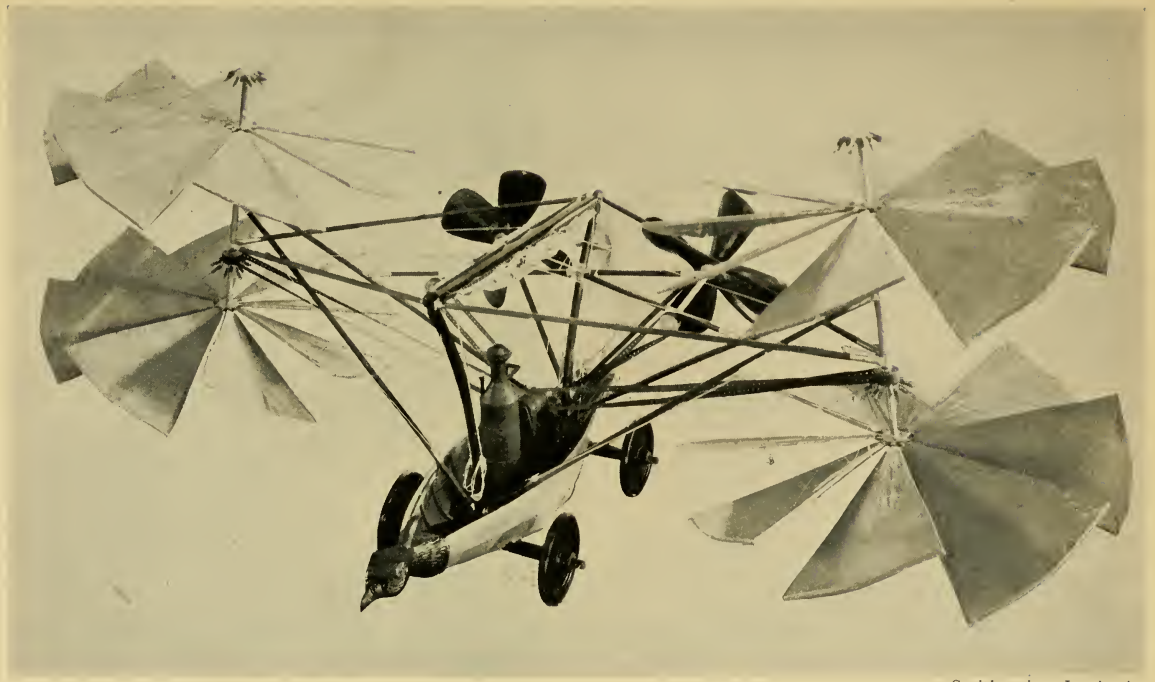
In 1843 the Aerial Transit Company ventured timidly to ask aid of Parliament — something in the way of a modest subsidy for these new experiments to navigate the ocean which came to every man's door. But Parliament was agonizing over the Corn Laws. England was in the grip of the profoundest misery that it had ever experienced. The industrial

revolution which had changed England from an agricultural to a manufacturing country had brought extraordinary hardships in its train, and had filled workhouses with starving men. All in all, it was a very bad time for two struggling inventors to ask aid for the creation of a new mechanical devil. And so Parliament said No, said it emphatically, and went back to the Corn Laws.

Under these circumstances it could hardly have been expected that any public contribution would fatten the treasury of the Aerial Transit Company. And none did. Henson, Stringfellow, and their partners scraped and saved where they could, but they had no money for the building of any machine larger than of model scale.

On paper, however, they put ambitious plans for the steam carriage Ariel. It was to have a wing span of 150 feet; its width was to be 30 feet. Linen or silk was to cover the wings. The design called for diagonal wire bracing and king posts. A two-cylinder steam engine developing thirty horsepower was to drive the craft by turning two six-vaned fans measuring ten feet in diameter. There were wheels under the car and an inclined runway was to launch it. There were to be 4500 square feet of supporting surface, and the total weight of the craft, including 600 pounds for engine and boiler, was to be 3000 pounds.

Then, one morning, Londoners came to their breakfast tables in a blaze of excitement. The *Glasgow Constitutional* (which certainly sounds, from this distance, like a respectable organ of conservatism) had flamed forth with an account of a flight undertaken by a Professor Geolls with Henson's machine, which had been constructed in the deepest secrecy. The London *Times* copied this account, which went through



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EARLY HELICOPTER

A Model of a Machine Proposed by Sir George Cayley (*Page 62*)

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THE FIRST MONOPLANE

A Model of the Design by William Henson (*Page 65*)

THE STRINGFELLOW TRIPLANE

One of the Earliest of Successful Flying Models (*Page 68*)

the minutest descriptions of the take-off, the flight over the River Clyde, and the disaster which befell the Professor when all his steam pipes burst at once. The report explained how he very naturally fell into the river and was happily rescued by a passing steamer. This account, said the *Times,* in the course of its editorial comment, must be absolutely accurate, since it was written by Professor Geolls himself.

This time the more cynical of the breakfasters were right. There was no Professor Geolls. Henson's steam carriage had never been built. The *Glasgow Constitutional* had permitted itself to go on a wild Scottish journalistic spree and had indulged in one of the favorite pastimes of the day — a journalistic hoax.

Henson and Stringfellow paid little attention, but went on with their sober, serious, painstaking experiments. Henson momentarily discarded his model steam engines and tried a spring for power. The model flew 60 or 80 feet, after being started down an inclined plane. Here was encouragement — and it immediately prompted him to return to his steam engine. Once again he met with failure. Once again he went back to a mechanism composed of clockwork and spring. But luck had now deserted him even here, and the onlookers in the Adelaide Galleries jeered his failures as onlookers love to do.

By this time Columbine the attorney and Marriott the journalist had had enough of these foolish adventures. Henson and Stringfellow bought them out, and carried on the Aerial Transit Company themselves. But public faith in Henson had vanished. When he and his partner built their next model, they found it necessary to try it out at night in order to avoid public ridicule. The grandfathers of people who

used to cry, "Git a hoss!" when the automobiles of the early century broke down publicly on the streets were active even then.

And they ruined William Henson. He was a sensitive man. He had stood as much of jeering, ridicule, abuse, misunderstanding, discouragement, as he could. With one gesture, the father of the monoplane, the man whose ideas impress us still to-day with their practicality and rightness, swept his years of thought and work and sweat and study into the discard and sailed for America, to be swallowed up somewhere in the state of Texas, never to appear again.

But John Stringfellow was of ruggeder build. Nor had he been through so long an apprenticeship of ridicule as Henson. He carried on alone.

Less than five years after his partner had vanished in Texas, John Stringfellow bumped suddenly and spectacularly into success. He had spent those five years in endless model experimentation. By 1848 he had things to his liking. He had a model plane ten feet in wing spread with an extreme width of two feet. He had two propellers, one right-handed, the other left. Each was four-bladed and sixteen inches in diameter. His engine had one cylinder, with a three-quarter-inch diameter and a two-inch stroke. Bevel gearing gave three revolutions of the propellers for every one of the engine. And the total weight of all this construction was less than nine pounds. Here was promise.

Stringfellow's plan was to launch the plane by letting it run down an inclined wire. The model was first tried early in June 1848, in a disused room sixty-six feet long and twelve feet high in a lace factory at Chard. On the first attempt, the elevator on the tail was set at too great an angle. The plane

soared for an instant, stalled, and fell back with a thump which broke its tail.

After minor repairs, the second try brought success. John Stringfellow's model plane flew the length of the room and stopped only when it struck the canvas placed to receive it.

Subsequently this model plane was taken to the Cremorne Gardens and flown outdoors for a distance of one hundred and twenty feet. Stringfellow had accomplished what his even more earnest partner had failed in. And he had carved for himself a niche in the aeronautical Hall of Fame, for he had become the designer of the first power-driven model plane to achieve successful directed flight.

Unlike most inventors, who are driven, usually, from one peak of effort to another, John Stringfellow was immediately content to rest upon his labors. He had done what he set out to do; he had received pleasing recognition and acclaim. He promptly abandoned aeronautics for a trip to the United States with his son, to travel in this vast, bewildering, and unknown country. But the fever for research, once acquired, seldom dies out completely. In John Stringfellow it did not reappear for almost twenty years. Not until the suggestion was made for the founding of the Aeronautical Society of Great Britain (this was in 1866) did he once again resume his studies. Then, although he was sixty-seven years old, he set about the construction of a triplane along the lines that Sir George Cayley had suggested years before. It never flew, but once again Stringfellow demonstrated his unique ability as the builder of small, compact, and efficient power plants — of almost watchlike delicacy, but of sturdy power. This new engine developed almost one horsepower for its weight of sixteen pounds. It was exhibited proudly at the first

Aeronautical Exhibition held in 1868 at the Crystal Palace.

It won for its inventor a prize of one hundred pounds as the lightest engine in proportion to its power that had ever been built in the history of mechanics. Its power was ample for flight; the trouble which Stringfellow could not overcome was that the rush of wind, when flight began, almost always blew out the flames under its boiler.

With his rekindled enthusiasms still high, John Stringfellow used his hundred-pound award for further research. But he was close to seventy now; his sight had failed and he was too old for much more accomplishment. With Henson and after him, he had devoted almost half of his life to the conquest of the air. And he, like Sir George Cayley before him, died leaving the world of aviation immensely in his debt.

VIII

THE BALLOON COMES BACK

THREE chapters ago we left the balloon suspended in mid-air, shortly after the violent death of Pilâtre de Rozier and M. Romaine. For ten years thereafter the history of aerostation is almost a total blank. Men were frightened by the disaster which took the first toll in the conquest of the air. But by the middle of the last decade of the eighteenth century, courage was returning. There were to be many days of lustre left in the history of the balloon.

France, for almost twenty years, disappears from the history of aerostation. Scarcely had French aeronauts recovered from the shock of the death of De Rozier when the fall of the Bastille in 1789 heralded the beginning of the Revolution. The desperate years that followed effectively put a stop to scientific progress. It was not to be until the year 1804 that the science of aerostation returned to the country that had given it birth. When history once again picked up its broken threads the locality of experiment turned out to be Italy. It was at Bologna in 1803 that Count Zambeccari, an Italian nobleman, retrieved what was by way of becoming the lost art of navigating the air.

Zambeccari had been for some time in the Spanish service against the Moors. In 1783 he had fled to Paris from the Inquisition and thence made his way to England. He had been immediately impressed with Montgolfier's "flying globes"

and decided to try them himself. He sent up his first Montgolfière on November 4, 1783, from the house of an Italian living in Cheapside. This experiment, made with a balloon only five feet in diameter, was private, but was seen by many. On November 25, Zambeccari launched a balloon twice the diameter of the original. It was sent up from the Artillery Ground at Moorfields and two and one-half hours later was picked up forty-eight miles away, where it was exhibited in a local barn at a price of one penny a person. These, if we except the soap bubbles of Cavallo, were the first aerostatic experiments to be performed in England. Zambeccari made his first ascent in 1785, in the company of Admiral Sir Edward Vernon.

Count Zambeccari has the further distinction of being the first man in history to undertake a night ascent. This distinction was come by inadvertently. For the flight in 1803, he and two companions, Dr. Grassatti and Signor Andreoli, had worked all day to get a large Montgolfière into condition for an ascent. All day long they worked without food. Darkness found them still toiling, and a large and impatient crowd watching their attempts. Zambeccari became the victim of the mob which had gathered to see a balloon ascent. It was not going to disperse until it saw one, and it wanted to see one *now*. So menacing did these gentle Bolognese become that at midnight, the Montgolfière being ready, the Count and his companions mounted the car, cut the ropes, and soared up, with nothing but the fire in the grate and the feeble light of a few lanterns to give them vision. The month was October. The balloon rose with such rapidity that the fingers of all three voyagers were shortly frostbitten. Still the ascent continued. Zambeccari and Dr. Grassatti lost con-

sciousness, obviously because of the combination of weakness from lack of food and an insufficient supply of oxygen. Not for two hours did the descent begin. Zambeccari and Grassatti returned to consciousness — which must have seemed to them a doubtful pleasure when they discovered that they were about to fall into the Adriatic Sea. They threw out ballast; not, however, before the car had sliced into the waves and drenched them with water. Then this extraordinary and perverse aerostat rose again to a sufficient height to sheathe the dripping aeronauts in a casing of ice. Grassatti became afflicted with that humiliating mishap, a nosebleed. Temporary deafness smote all three. Speech became first difficult, then impossible. Descent began again at 3 A.M. Only a few minutes later the basket of the Montgolfière struck the waters of the Adriatic, this time not to rise. From a little after three in the morning until eight o'clock these miserable Italians stood in the basket of their balloon with chilly water up to their waists. Finally help approached. A little fishing boat, spying the strange object, started to the rescue. The tired hearts of the three aeronauts beat a little faster.

So did the heart of the fisherman. The closer he got to the Montgolfière the less he liked it. Nothing like it had ever swum within his ken before. It was, he decided in a flash of panic, a sea monster.

In consequence of which, Zambeccari and his companions, beyond profanity, beyond tears, beyond now hope of life, dully watched this Adriatic fisherman head his craft about and sail away with all possible speed.

The next fisherman was made of sterner stuff, as the result of which he gets his name into history. He was Antonio Bazol, and he kept his courage up sufficiently to rescue the

three unfortunates at a little after eight o'clock in the morning. It had been an effective but disastrous voyage. Zambeccari had reached a height of over five miles, but he lost two fingers from one hand as the result of freezing.

Even then the sufferings of Zambeccari were not over. His misadventures contrast oddly with the joyous flights of his countryman, Vincent Lunardi, of whom the ladies were so fond. Later he again fell into the Adriatic. On another occasion he had just set off with a passenger when his Montgolfière caught fire. His passenger scrambled down the anchor rope, while Zambeccari stayed by his ship and managed to extinguish the fire in the air. On one last occasion, however, he was not so lucky. His final flight came in 1812, once again from Bologna. In rising, the balloon collided with a tree. The spirit lamp which rarefied the air upturned and set fire to the car. The flames spread too fast to be extinguished. Fifty feet above the earth the brave Zambeccari jumped, to be instantly killed when he struck the ground.

But, despite the disasters of Count Zambeccari, aerostation had taken on fresh enthusiasms. New experiments flourished; so did luscious imaginings of aerial machines. The most extravagant and impossible suggestion for an aerial machine which the world had ever seen, or probably ever will see, came about when a gentleman by the name of Robertson, in 1804, published his project for La Minerva, a world-touring aerostat capable of carrying 150,000 pounds and accommodating sixty persons. One must see the illustration facing page 82 to be able to appreciate it.

According to Robertson's plan, the sixty passengers would be carefully selected by various academies. They would stay aboard several months, rise to all possible elevations, pass

through all climates and seasons, and make scientific observations. Geographic exploration would be well served. Over hot deserts, the Minerva could easily rise to cooler temperatures. It could take advantage of favorable winds and make a tour of the world. With full supplies, it could, if necessary, take six months to cross the Atlantic. So said Robertson.

As a matter of fact, the poor Minerva would have had trouble in crossing any body of water, even a meadow brook. That you may more fully and clearly picture her wonders, here is a description of the machine as given by the richly endowed imagination which conceived her. Few modern homes afford so many luxuries.

The cock (3) is the symbol of watchfulness; it is also the highest point of the balloon. An observer, getting up through the interior to the point at which the watchful fowl is placed, will be able to command the best view to be had in the Minerva. The wings at the side (1 and 2) are to be regarded as ornamental. The balloon will be 150 feet in diameter, made expressly at Lyons of unbleached silk, coated within and without with India rubber. This globe sustains a ship, which contains or has attached to it all the things necessary for the convenience, the observations, and even the pleasures of the voyagers.

(*a*) A small boat, in which the passengers might take refuge in case of necessity, in the event of the larger vessel falling on the sea in a disabled state.

(*b*) A large store for keeping the water, wine, and all the provisions of the expedition.

(*c, c*) Ladders of silk, to enable the passengers to go to all parts of the balloon.

(*e*) Closets.

(*h*) Pilot's room.

(*l*) An observatory, containing the compasses and other scientific instruments for taking the latitude.

(*g*) A room fitted up for recreation, walking, and gymnastics.

(*m*) The kitchen, far removed from the balloon. It is the only place where a fire shall be permitted.

(*p*) Medicine room.

(*v*) A theatre, music room, &c.

(–) The study.

(*x*) The tents of the air marines, &c. &c.

This was not a balloon; this was an estate. Robertson was extravagantly proud of it. Having proposed it at Vienna in 1804 and having met with no encouragement, he bided his time. In Paris, sixteen years later, he brought out his prospectus once again. "There is no limit to the sciences and the arts which cultivation does not overstep," he said. "We have everything to hope and to expect from time, from chance, and from the genius of man."

True words; surprisingly true to have come from the creator of the Minerva.

In the same year that Robertson first proposed his gaudy absurdity, aerostation returned triumphantly to France. Joseph Louis Gay-Lussac, a French chemist, whose name is often bracketed with that of the physicist Charles, resolved to undertake scientific studies of aerostation and the nature of the atmosphere with an exactness that no one before had attempted.

The French government furnished the balloon, which was the same one Napoleon had taken to Egypt to assist in the capture of Cairo. On August 23, 1804, Gay-Lussac, with his assistant Biot, rose from the Conservatoire des Arts, in

Paris. There were no great crowds, no cannons fired, no picturesque Lunardi farewells; this was a sober, serious, scientific expedition. By the standards of the day, the scientific equipment was complete. There were barometers, thermometers, hygrometers (combinations of wet and dry bulb thermometers for the determination of humidity), electrometers, two compasses, a fine needle carefully magnetized and suspended by a silk thread, several wires from sixty to three hundred feet in length, and a small electrophorus — a machine which will produce static electricity by induction. For further electrical experiments, they carried a voltaic pile, discs of zinc and copper, and a number of those animals so indispensable to the electric experimenter of the eighteenth and nineteenth century — frogs. And to capture specimens of air at high altitudes they carried also flasks fitted with stopcocks and exhausted to the highest possible vacuum obtainable in those days.

Gay-Lussac and Biot began their experiments at an altitude of 6500 feet, after they had successfully pierced a cloud and emerged into the clear atmosphere above. Was a magnetic needle, at this altitude, attracted as usual by iron? They found it was. How about the action of the voltaic pile? At this altitude twenty pairs of plates performed as usual. Wires attached to them and placed on the tongue caused an acid taste. The nervous reaction of muscles appeared to be the same. Water was, as usual, decomposed into hydrogen and oxygen.

By the time that Gay-Lussac and Biot had reached a height of 8600 feet, the animals of the expedition began to suffer. These the experimenters had taken along for studies in physiology. But a bee, they discovered, was in no way embarrassed

by the altitude; when released he hummed swiftly away. The one physiological change so far noted was in Biot's pulse rate; the normal 72 beats per minute had risen to 111, because the lessened oxygen of the atmosphere required a quickened heartbeat. But the force of magnetic attraction and the action of the voltaic pile remained the same.

At 11,000 feet they released a green linnet. It was only for a moment discommoded. It flew away, returned to the car, and then flew straight toward earth. So did a pigeon, released a few moments later. Finally the scientists descended near Meriville, having traveled about fifty miles from Paris.

This was the first of three historic flights. The second benefited by the experience of the first, and the great M. Coulomb, who loomed large upon the horizons of electricity in those days, himself adjusted the dipping needle. Once again the experimenters carried electrical equipment and glass flasks exhausted to the equivalent of $\frac{1}{25}$ of an inch of mercury.

On the morning of September 16, 1804, Gay-Lussac made his third and most successful scientific ascent. He rose and rose and rose, until the mercury in his barometer showed 12.95 inches. He developed a headache. No wonder: he had risen to a height of 23,040 feet and broken every altitude record of the day. Even as late as the year 1910, the airplane had still achieved less than half the height that Gay-Lussac rose to more than one hundred years before.

At heights a little over 20,000 feet Gay-Lussac took his air specimens. When he descended at 3.45 in the afternoon, sixteen miles from his starting point, he rushed with his precious flasks to the laboratory at the École Polytechnique in Paris. There, in the presence of Thénard and Gresset, he analyzed his air. It was about half as dense as the air at sea level, but

the proportion of oxygen, two hundred and fifteen parts for every total thousand, was identical.

Science had made its first experiments in an unknown region.

IX

GREAT NASSAU AND MR. GREEN

Charles Green and the Great Nassau Balloon deserve a chapter to themselves. Green, although not a scientist, was by all odds the most illustrious practitioner of aerostation in his day. The Great Nassau Balloon was one of the first real trail breakers of the sky.

Charles Green was born in 1785 — the year that Jeffries and Blanchard first crossed the English Channel. He was the son of a London fruiterer, and he joined his father in business when he left school. His first interest in aerostation came about as the result of experiments which he made with an apparatus for making gas, by means of which he proposed to light "his own premises." He suspected that coal gas, like hydrogen, was sufficiently light to buoy up a balloon, and he tried out small globes to make certain. It was.

Green made two spectacular contributions to aerostation. The first was his substitution of ordinary coal gas in place of the more expensive, fugitive, and inflammable hydrogen; the second was the "guide rope."

His use of coal gas to replace hydrogen was ingenious and effective. It was not so buoyant as hydrogen, but it had, notwithstanding, four great advantages: it was less injurious to the silk envelope; inflation could be much more rapid; it diffused away much more slowly; it was only one sixth as expensive. Naturally, gas companies loved the idea.

Green invented the guide rope to avoid the constant necessity of alternately throwing away gas and ballast. To the car of his balloon he attached a rope one thousand feet long. When his freshly distended balloon arose and went to an altitude of more than this length, the balloon supported the entire length of the rope. When this burden became too heavy, the balloon would begin to sink, and the rope to trail a certain fraction of its length along the ground. The balloon therefore would soon achieve something like equilibrium between the weight of the rope and the lifting power of the gas, and the desperate refuges which cost Blanchard and Jeffries the loss of food, drink, gear, and trousers would be avoided. This, at any rate, was the theory; and it worked excellently so long as the guide rope did not tangle itself up in obstinate ground structures which might resist aerostation. Green, like the good practical man he was, was anxious to see how well his invention would work in a grueling long-distance flight.

The result was the Great Nassau Flight — first new milestone of significance to be passed in the history of aerostatic exploration since Jeffries and Blanchard crossed the English Channel in 1785. Green was in charge. His fellow passengers were Monck Mason, an early historian of aerostation, and Robert Hollond, by profession a lawyer and a Member of Parliament from Hastings. The flight was great not only then; it remains after almost one hundred years one of the greatest ever made in a balloon.

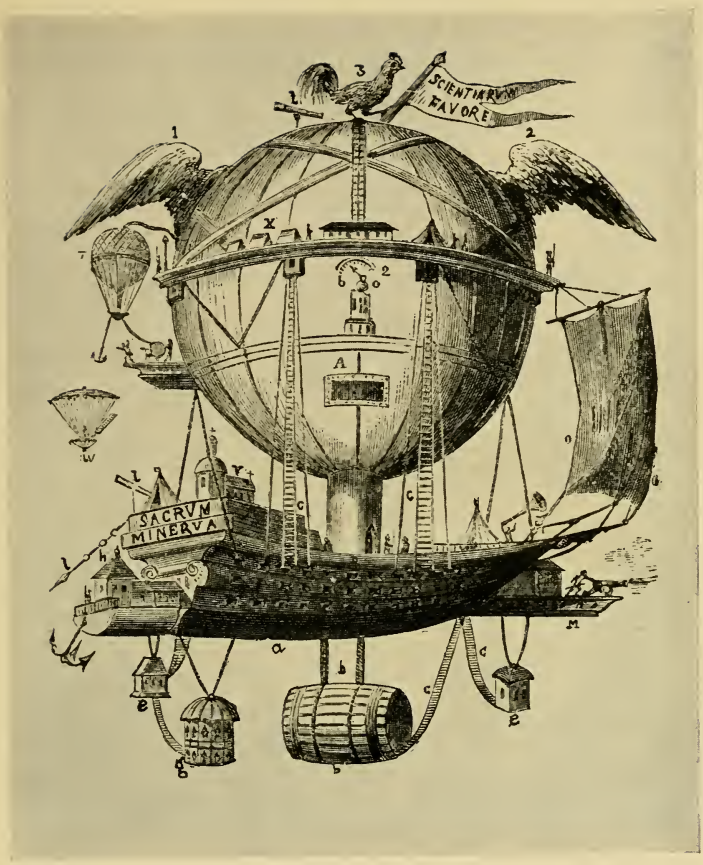
The aerostat, which was at first called the Vauxhall Balloon because it was constructed to rise from Vauxhall Gardens, in London, was a huge affair. In shape it somewhat resembled a pear, because, in the words of Monck Mason,

this presented "a form and proportion admitted to be at the same time most consistent with elegance of appearance and most adapted to the wants and circumstances of aerostation." The height was more than 60 feet; the diameter about 50. Fully distended, it contained some 70,000 cubic feet of gas and had a total lifting power of about 4000 pounds beyond its own weight of 1000 pounds. An oval wickerwork car, nine feet by four feet, had seats for three persons at each end and was stocked with provisions for a fortnight. Could Englishmen go on a trip of this length without tea or coffee? They could not. But what about the dangers of an open-flame stove within a few feet of 70,000 cubic feet of "carburetted gas"?

Mr. Green's answer was a stove specially designed to utilize the heat that quicklime gives off when it is slaked with water. Unfortunately, Mr. Green's manual dexterity did not match his inspiration; he fumbled his stove somehow, and dropped it overboard during the first night of the voyage.

At 1.30 in the afternoon of Monday, November 7, 1836, Green, Mason, and Hollond set forth from Vauxhall Gardens. It was the sixth ascension for their craft. The public was not privileged to view the departure at close range, and the crowd outside bulged inward the fences of the Gardens in eagerness to watch the great pear-shaped white and crimson aerostat go up.

Go up it did, upon its voyage with regard to which the three passengers had only one determination — to go as far as possible, in whatever direction. The car was generously loaded: sandbags, provisions, cordage, cloaks, carpetbags, barometers, megaphones (called "speaking trumpets" in those days), telescopes, a lamp, a wine jar, and other provi-



THE POOR MINERVA

Perhaps the Most Elaborate Absurdity Recorded in the History of Aerostation (*Page 74*)

THE GREAT NASSAU

The Famous Balloon of Mr. Charles Green (*Page 80*)

sions for a supposed two-week voyage. All in all, it was one of the most thoroughly planned expeditions in the history of travel. The aeronauts even took passports to every country on the European continent; special passports which specified the peculiar nature of the voyage and entitled the holders to "exemption from the usual formalities of office." Herein they scored a beat; they thought of something which, ninety years later, Clarence D. Chamberlin forgot.

Hollond kept the log. The day was unusually fine, with cool, light clouds. At 4.15 P.M. the aeronauts sighted the North Sea, and drifted over the same Dover Castle whose governor had earlier called Dr. Jeffries to account. They passed the chalk cliffs, much to the annoyance of a colony of rooks.

Said Monck Mason: "There is no situation conceivable from which the beauties of nature are seen to greater advantage or with more singular effect than that wherein the spectator is placed, when, seated in a balloon, he happens by circumstance to be brought into closer approximation with the earth beneath." He was, one gathers, pleased. Unlike the perilous voyage of Blanchard and Jeffries, the Great Nassau Balloon carried the Messrs. Green, Mason, and Hollond so swiftly over the English Channel that within an hour they were viewing, through the deepening twilight, the fields of France. Green had hoped to try his guide rope over water by the use of copper floats, but his sturdy craft held him up so high that the experiment was never possible.

Once over land again, Green threw out his thousand-foot guide rope. By now it was completely dark, and the earth below looked starry from the scattered lights of towns. It rivaled, said Monck Mason, the "remoter lustre" of the

heavens. The aeronauts relieved the monotony of night by guessing games: "What town is that?" "What country is this?" They rightly concluded they were over Belgium when they passed a "fiery region" that could have been nothing else but the iron smelters of Liége.

The guide rope was proving invaluable. It warned them of approaching hills. Now and then, even to-day, an aeronaut in dark or fog is disconcerted by bumping into a mountain. But for Mr. Green's invention the same disaster might have overtaken the Vauxhall Balloon. Warned by the guide rope, however, they were able invariably to throw out ballast in time.

A new day wore on. And it soon became obvious to the aeronauts that the duration of their voyage would be far short of two weeks. They knew they had covered a great distance — just how much they were not sure, but certainly far more in less than a day than they had expected to cover in several. But agreement had been made that the balloon would be exhibited in Paris. It was well not to go too far. An early landing seemed desirable, but the point of landing was much in doubt. Forest land stretched away in every direction. Finally the straining eyes of Mr. Green made out a small grassy vale surrounded by mountains. The balloon had now very little altitude. Green threw out his grapnel, but the wind drove them beyond the clearing before it caught ground. Only a hasty discharge of ballast saved them from collision with the next mountain.

In the next valley beyond, two German women standing in a path in the woods saw this same experience repeated. Finally, however, at 7.30 in the morning, the aeronauts sighted a third landing place. This time the grapnel did catch; Mr.

Green valved the carburetted gas; and the great Vauxhall Balloon settled slowly down to earth. A group of peasants surrounded it.

"Where are we?" asked Mr. Green.

"The Duchy of Nassau. And where do you come from?"

"London. We left yesterday afternoon."

There was silence after that. It was not so much a silence of respect as one of contempt. From London to the outskirts of Weilburg, a distance of five hundred miles, in eighteen hours? What fearful liars the English were!

These strained international relations were handsomely restored a few moments later when Mr. Green handed out biscuits and wine. This brought about not only the restoration of credulity, but willing assistance with the task of folding up the immense balloon for storage in a cart. It was noon, however, before the efforts of the Germans accomplished this. Mr. Green's wage scale seems to have been overhigh. His doles had the startling effect that all fourteen of his heavily bearded and entirely unwashed co-workers tried to kiss him, to kiss also Monck Mason and Mr. Robert Hollond. A new international crisis seemed imminent; fortunately the timely arrival of the horse and cart to take the balloon back to Weilburg avoided these complications.

On the day before its departure for Paris, the Royal Vauxhall Balloon was rechristened the Great Balloon of Nassau by Mlle. Theresa, daughter of Baron Debra. It was a grand ceremony and there were loud demonstrations of amity. To the Duke of Nassau, Charles Green presented the flags which his expedition had carried. The return to Paris was a graphic illustration of the wonder that aerostation was in the world of 1836. From London to Weilburg had taken eighteen

hours; from Weilburg to Paris took six days and six nights.

Charles Green went on to fresh flights. The Great Balloon of Nassau became a national institution. It made many ascents from Vauxhall Gardens and carried many varieties of cargo. It was even advertised to take up a military band, which burst forth some five hundred feet above the ground. A lottery came to be held almost daily. Six numbers were drawn from a hat and the six lucky holders were permitted to go up with Mr. Green, or to sell their chances for what the market would bring. But by 1840, Green had tired of this. He had been making balloon ascensions for nineteen years and had totaled 275 voyages. He decided that he would get a pleasant thrill out of crossing the Atlantic. Aerostation had again become ambitious.

Green admitted obstacles. Moisture would collect on the gas bag in the fog at night; much leakage of gas was to be expected on so long a trip; the difficulty of maintaining a constant altitude would be extreme. Still Mr. Green was not disturbed. An unusually long guide rope, he felt positive, was all that was necessary. At a height of 10,000 feet the winds, in his opinion, were prevailingly west or northwest, and a start from America would, if proper altitude were maintained, almost inevitably land him in England. He called the trip an " excursion " and offered to make it if some wealthy man would pay expenses. " I shall be ever ready and most happy gratuitously to contribute my services."

Here was courage. Remember that in the year 1840 the Atlantic was respected far more than to-day. No giant quadruple-screw, oil-burning, turbine-driven express liners had shrunk the time of crossing to less than five days. It had been only twenty-one years before that the 350-ton Savannah,

OVER LIÉGE

Green, Mason, and Hollond on Their Famous Voyage to Weilburg (*Page 84*)

Music in the Clouds.

EXTRAORDINARY NOVELTY.

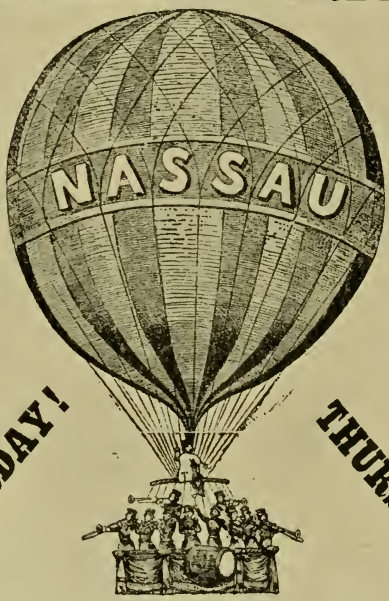
ASCENT OF A MILITARY BAND

Consisting of Ten Instrumental Performers, under the direction of Mr. DEAN.

FROM

VAUXHALL GARDENS,

THURSDAY, September 2nd, ANOTHER Military Ascent, IN COMPLIANCE WITH THE Expressed Wishes OF A LARGE CONCOURSE OF VISITORS Who Witnessed THE PREVIOUS ONE ON Monday Last.



THURSDAY, September 2nd, ANOTHER Military Ascent IN COMPLIANCE WITH THE Expressed Wishes OF A LARGE CONCOURSE OF VISITORS Who Witnessed THE PREVIOUS ONE ON Monday Last.

THURSDAY!

THURSDAY!

The ASCENT will take place at Half-past 6, when the Band will commence a performance of Popular Airs, to ascertain at what distance sound can be heard in the Air

DOORS OPEN AT HALF-PAST 5. ASCENT AT HALF-PAST 6.

Admission ONE SHILLING.

H. Green, Engraver, Printer, and Lithographer, 64, Stones End, Borough.

Vail Collection

AERIAL ADVERTISING

Announcing "Music in the Clouds" *(Page 86)*

Captain Moses Rodgers, had made the first crossing with steam as an aid to sail. It had taken her twenty-five days to travel from Savannah to Liverpool. Even the exploits of the Flying Cloud were over a decade in the future. Had some wealthy man, as Mr. Green fondly hoped, come forward with cash, the chances are strong that Mr. Charles Green would never have found the leisure to die in bed of heart failure at the age of eighty-five. He renewed his proposal in 1846, but again it found no backer.

Even after thirty-one years of ballooning, Charles Green s enthusiasms were still fresh, his search for aeronautical novelty still avid, his knowledge of the sweet uses of publicity still keen. By 1852, balloon ascensions had lost their grip upon the public. The novelty which once drew " vast concourses " of people to Versailles, to the Champ de Mars, to Chelsea Hospital, to the Royal Artillery Grounds, to the Vauxhall Gardens, had vanished.

So at the Cremorne Gardens, one August day, Mr. Green gave the populace a new thrill. He dispensed with any car and fastened to his balloon two broad slings which went under the belly of a pony. Proudly astride the pony's back, he made an ascent. At first the pony plunged violently, almost throwing his rider in mid-air. Later, seeming to find that there was nothing he could do about it, he became reconciled, and he and Mr. Green descended near Shooter's Hill, Kent.

Later, others tried the same engaging experiment. One of them, a Madame Poitevin, was promptly haled into court by the agents of the Royal Society for the Prevention of Cruelty to Animals. At the first trial the charges against her were quashed on the ground that the ascent was made, and therefore the crime, if any, committed at a point outside the

jurisdiction of the presiding justice. The infuriated agents of the Royal Society, seeing their victims almost slipping from their grasp, achieved a speedy change of venue. Mr. Justice Arnold's courtroom at Westminster was jammed. The most picturesque moment of the trial came when M. Poitevin testified that he had made one hundred and fifty such ascents, all with one horse, and that the horse loved it. There could be no possible suffering, said M'sieu. Horses were much less comfortably slung when being put aboard ship, said M'sieu. Immediately on landing, his own horse would start unconcernedly to grazing. More than that: when descents were sufficiently slow and gentle, the horse was so completely at ease that he would spend several moments in grazing from off the tops of trees before he landed, said M'sieu. Why should the equine stomach be deprived of privileges open to giraffes?

This remorseless logic could bring about only one outcome. Mr. Justice Arnold's decision was that Madame Poitevin was not guilty.

Not until 1857 did Charles Green retire from aerostation. In that year, he made his five hundredth and last ascension. Curiously, for a man so open-minded to suggestion and so anxious to try all experiments, Mr. Green doubted any future possibility of steering balloons. A newspaper of the day took him to task. "That it is beyond our power at present is admitted. But what steers a bird? What steers and carries the wild swan, as heavy as an infant, a thousand miles ahead of the tempest and *against* the tempest? The united action of the wings and tail. The buoyancy of the balloon would render the wings unnecessary, except for addition to the steerage power. The true and only difficulty to be mastered is

that of enabling the balloon to go faster or slower than the winds; for it is only in such cases that the rudder can have anything to act upon."

Truth! The science of aerodynamics was by slow degrees progressing. Mr. Green, his five hundred ascents safely completed, all records for distance and frequency in his proud possession, was entitled to die in his bed of heart failure on March 26, 1870, secure in the knowledge that he had won for himself a great place in the growing gallery of men who were blazing the trails of the sky.

X

THE ZENITH OF THE BALLOON

The five decades between 1820 and 1870 saw the zenith of the balloon. The stirring example of Charles Green inspired many a young man to go and do likewise. The record of personal bravery, achievement in duration of flight, and so on, is impressive. Scientifically, experimenters accomplished little. Lacking proper motive power, the idea of a dirigible proposed by General Meusnier and furthered by Sir George Cayley remained only an idea.

Yet meanwhile an illustrious group of young men were growing up to follow in the footsteps of Charles Green. One of the first of these was Henry Tracey Coxwell, who was born in 1819 at Wouldham, England. He was greatly excited when, as a boy of nine, he saw Charles Green ascend from Rochester. When he came to maturity, he was apprenticed to a dentist, but, by his own confession, his thoughts remained "always on balloons" — probably to some small disadvantage of the dentist's patients. At the age of twenty-five, he made his first ascent, after, in August 1844, he had helped John Hampton to build a new balloon.

One year later, in September 1845, he founded the first English aeronautical magazine and became its editor and publisher. This was the *Balloon or Aerostatic Magazine.* Its reception was good, but public demand did not keep pace with the enthusiasms of the editor — who, for aeronautical

purposes, had always called himself "Henry Wells, Esq." The magazine continued to consume funds at that rate which is always so startling to amateur publishers, and presently Henry Wells, Esq., went back to the strictly practical aspects of aerostation.

Coxwell, with James Glaisher, on September 5, 1862, made one of the most remarkable balloon ascensions in all history. It had been undertaken on behalf of the British Aeronautical Association, and was one of the first purely scientific voyages that had been undertaken since the brave days of Gay-Lussac and Biot. Its first purpose was to determine the temperature of the air at different altitudes. The aeronauts were also to obtain samples of air, note the height of the clouds, make observations on sound and on atmospheric phenomena in general.

The two went up from Wolverhampton in the early afternoon. Within the first half hour they had ascended four vertical miles. At five miles Glaisher was affected by the rarefied air. First his sight was troubled; then a paralysis of arms and legs overtook him. He next lost his power of speech. At 29,000 feet he lost the only thing he had left to lose — consciousness.

Coxwell was still alive and awake, but extremely weak. His attempt to scrape frost off the neck of the balloon froze his hands so badly that he could not use them. After several attempts, he managed to seize the valve line in his teeth and the descent began — but not until Coxwell and Glaisher, in the year 1862, had gone up 37,000 feet, or over seven miles.

Henry Wells, Esq., was made of stern stuff. You will give him all the more credit when you reflect that a flight to 41,000 feet in an airplane was front-page news in May 1929, and that

for this flight the aviator, Willy Neunhofen, had modern conveniences like oxygen flasks and electrically heated clothing — both quite beyond the imagination of Henry Coxwell.

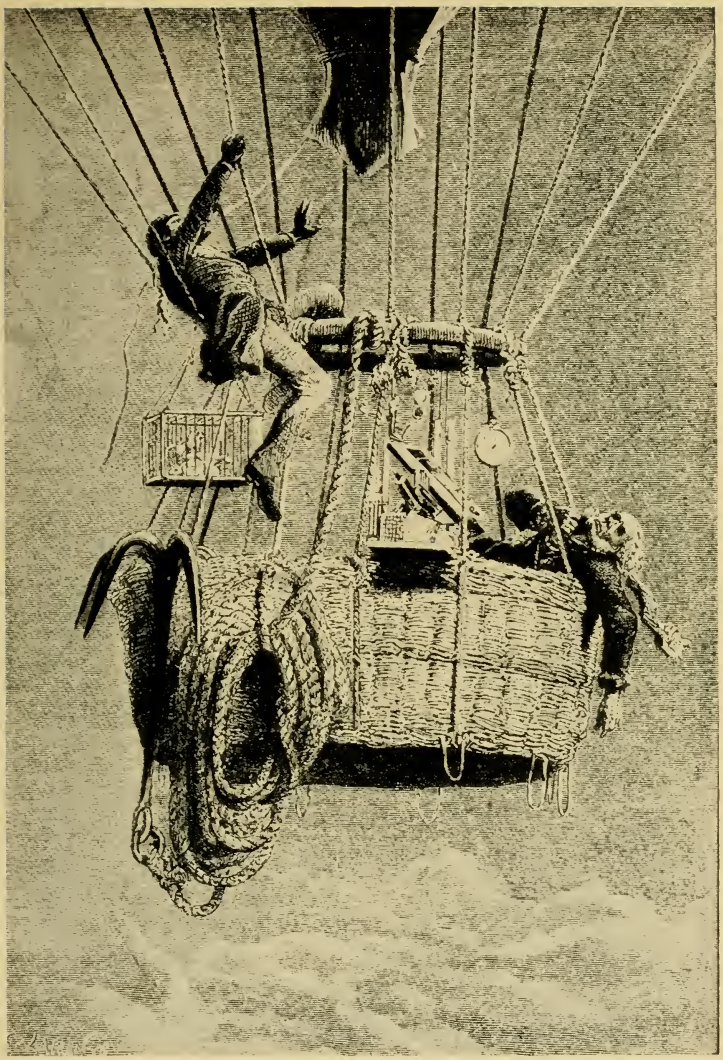
Within the next few years he lived a busy aerostatic life. He became deeply interested in the balloon as a military adjunct, not only for observation, which had already been tried, but for such humanitarian purposes as dropping bombs on towns. In 1863 he took up officers of the Royal Engineers and demonstrated to them the great value, obvious to General Meusnier years before, of the balloon for military observation. But the English high command did nothing.

Coxwell had made many ascensions in Germany. When the Franco-Prussian War broke out in 1870, he devoted himself, and with excellent effect, to the instruction of the newly created German Balloon Corps, which operated in the campaign against Strassburg.

In 1873, three years after the death of Charles Green, Coxwell acquired the Great Nassau Balloon. By now he had exceeded even the record of the man who had been his first inspiration. He had made his five-hundredth ascent ten years earlier. Not until 1885 did he make his last.

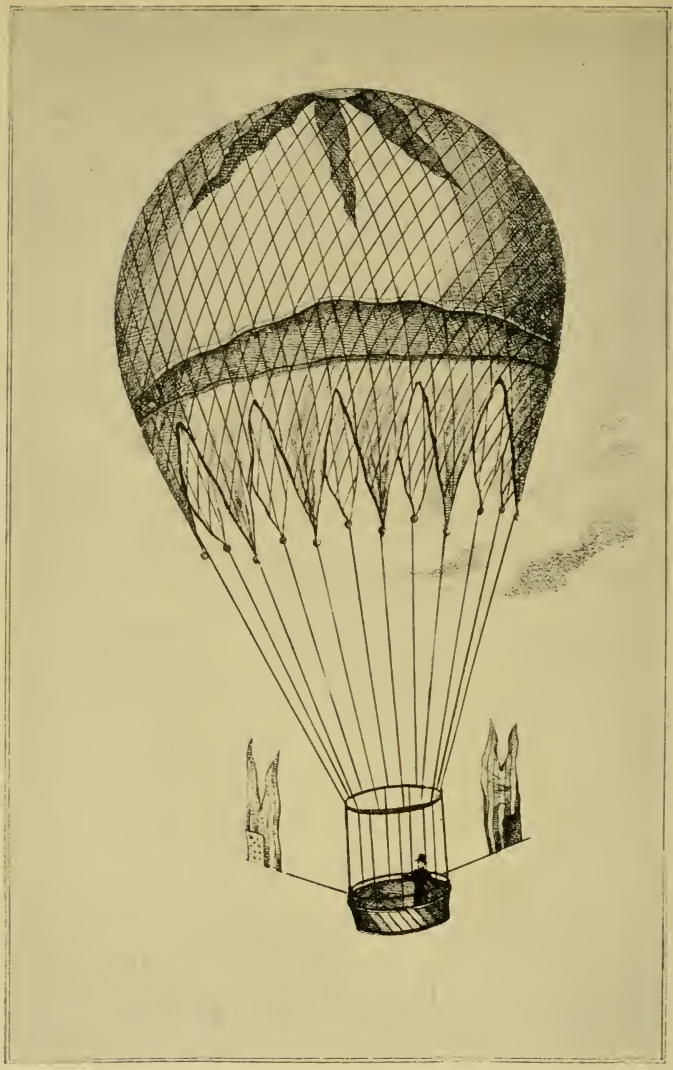
Henry Coxwell lived out his century by five days. He died at Seaford, in Sussex, on January 5, 1900. He was a gifted, skillful, and experienced aeronaut, but a narrow and bigoted man. He had more faith than Charles Green in the eventual conquering of direction by balloons, but his hatred of heavier-than-air machines was almost fanatical.

Aerostation now returns to the United States. In 1783, you will remember, the Messrs. Rittenhouse and Hopkinson had constructed, and James Wilcox had ascended in, a hydrogen balloon. Since then, however, aerostation slumbered



ALTITUDE RECORD

The Amazing Seven-Mile Ascent of Coxwell and Glaisher
(Page 91)



JOHN WISE SAVES HIS LIFE

When His Balloon Exploded, He Used It as a Parachute
(*Page 93*)

in the new country, which was too busy finding itself to have much time for other matters. Finally it reappeared in the city of its birth in America. Young John Wise made his first ascent from the corner of 9th and Green Streets, Philadelphia, on May 2, 1835.

One of his most thrilling experiences came early in his career. On August 11, 1838, he ascended from Easton, Pennsylvania, only to find himself in a thunderstorm. To avoid it he rose to an altitude of 13,000 feet, and found that, although he had escaped the dangers of being struck by lightning, his balloon was dangerously distended and apparently about to burst. He was wondering what to do when the balloon took matters into its own hands and settled the question for him. It exploded.

Now to be an aeronaut 13,000 feet up, in the car of a balloon which has just exploded, does not, ordinarily, lead to a long expectation of life or much chance of taking out new insurance. With gas roaring out of the rent in the bag, John Wise started on a swift descent. His two-mile trip ended a few moments later in the general vicinity of Easton. He was flung ten feet from his car and picked himself up entirely uninjured. The bag of the balloon had flared out as once it had with Henry Coxwell, acted as a parachute, and dumped him on to the ground with nothing more than a shaking up — or a "concussion," as the writers of the day, who disliked words under three syllables, would have said.

After that, nothing could frighten John Wise any more. He had had the worst aeronautic experience possible and had come through it uninjured. The rest of his life is a record of fearlessness. On several occasions he intentionally demonstrated the same principle that he had accidentally discovered

— namely, that a balloon may also be used as a parachute. He was thus the inventor of the rip cord.

Like Charles Green, John Wise believed from his observations that above twelve thousand feet a strong current of air blew constantly from west to east. Accordingly, in June 1843, Mr. Forney, the editor of the *Lancaster Intelligencer,* published for "general notice to the civilized world" the following remarkable statement: —

TO ALL PUBLISHERS OF NEWSPAPERS
ON THE GLOBE

As it is my intention to make a trip across the Atlantic with a balloon in the summer of 1844 [this was four years after Charles Green's first proposal; two years before his second] and as the descent or landing of balloons, in my experience, has almost universally created unnecessary alarm and consternation to the people near by, I therefore give this general notice to the seafaring community of all climes, that should they, during any time henceforth, chance to be in the vicinity of a balloon, either on the ocean or in the atmosphere, they need not be under any fearful apprehensions, but endeavor to give aid to its adventurers.

It must not be inferred from this that its success is considered improbable, but merely to be prepared for all emergencies.

Having, from a long experience in aeronautics, been convinced that a constant and regular current of air is blowing at all times from west to east with a velocity of *from 20 to 40, and even 60 miles per hour,* according to its height from the earth; and having discovered a composition which renders silk or muslin impervious to hydrogen gas, so that a balloon may be kept afloat for many weeks, I feel confident, with these advantages, that the trip across the Atlantic will not be attended with as much real danger as by the common mode of transition. [Remember that John

Wise had already fallen thirteen thousand feet without even spraining a finger; his ideas of danger, by now, were a trifle distorted.]

The balloon is to be one hundred feet in diameter, which will give it a net ascending power of twenty thousand pounds — being amply sufficient to make everything safe and comfortable. A seaworthy boat is to be used for the car, which is to be depended on in case the balloon should fail to accomplish the voyage. The boat is also calculated on in case the regular current of wind should be diverted from its course by the influence of the ocean, or through other causes. The crew is to consist of three persons — viz., an aeronaut, a sea navigator, and a scientific landsman.

Therefore the people of Europe, Africa, Asia, and all other parts, on the ocean or elsewhere, who have never seen a balloon, will bear in mind that it is a large globe made of cloth, ensconced in a network, with a sloop hanging underneath it, containing the latest news from the United States, and the crew of the world's obedient servant,

JOHN WISE.

This resounding announcement was generally published throughout the Union and in Europe. On December 20, 1843, John Wise, citizen of Lancaster, Pennsylvania, petitioned "the Honourable the Senate and House of Representatives of the United States of America in Congress assembled" for a naval appropriation to carry out his transatlantic flight. His petition was received, read, and referred to the Committee on Naval Affairs.

Seven years later, John Wise, slightly saddened, was still waiting to hear from Congress. A bit quieter, but still dogged, he said, in 1850, "Although its substance has not yet been accomplished, its postponement is attributed to a single cause — want of pecuniary means to do it *right.* If

Congress will *not* give the small appropriation necessary — ten or fifteen thousand dollars — to give it effect (I will not say to make an attempt, because its consummation is as certain as that a sail ship can do it), our wealthy merchants of Philadelphia and New York cities should take it in hand, since it would enhance their facilities so much."

This John Wise was a vigorous, robust, imaginative man. He demonstrated this anew in 1846 when this country was entangled in the midst of its unsavory Mexican War. Wise promptly proposed a plan for the capture of the inconveniently well fortified city of Vera Cruz. You would need, he told the War Department, a balloon of 100 feet diameter — one that could lift 30,000 pounds, including itself. This would mean a useful load of at least 20,000 pounds. You would load the car with 18,000 pounds of torpedoes and bombs. You would attach the balloon to a warship by a five-mile cable. The altitude of the balloon would be never less than one mile and the balloon would be completely out of range of the most powerful Mexican guns. Thus you could take the castle of Vera Cruz without the loss of a man.

The plausibility of this was too much for the War Department, which supposed that something must be wrong with it. The probabilities are strong that John Wise's plan was entirely feasible. But the plan was widely discussed in the newspapers. The Philadelphia *Public Ledger* — then, as now, cautious with its endorsements — thought it " difficult to enlist volunteers for that service." Wise wrote to Secretary of War Marcy and himself volunteered not only to go but also to raise the necessary crew of nine men, but nothing happened.

Although John Wise, largely because his ideas were too

vigorous for his placid times, never succeeded in making his great Atlantic flight, he did make one ascent in which, by odd coincidence, he traversed much of the route which was the preliminary to Lindbergh's triumphant hop in 1927. In 1859 he traveled during the course of less than twenty hours the distance of 1120 miles from St. Louis, Missouri, to Henderson. New York.

XI

GLIDERS EMERGE

Green, Hollond, Mason, Coxwell, Wise — this is the gallery of the illustrious in aerostation in the first half of the nineteenth century. They were great men, and their part was a spectacular part — but it was also in great measure an accidental one. Some of their greatest accomplishments had been almost inadvertent. Man's bravery had done great things; his brains had accomplished almost nothing toward solving the two great problems of power and direction. By the time of the American Civil War, aeronauts had entered into the semifinal stages of despair. Spectacular developments in lighter-than-air navigation were still to come, but for the time hope was all but dead. Once again the heavier-than-air machine began to loom large.

We have seen already how the brave start of the glider came to nothing. Sir George Cayley, who first made it a practicality, grew tired of it and strayed into the field of aerostation, as being the more likely one to cultivate. Henson and Stringfellow, who went on from where Cayley stopped, became quickly so engrossed with the idea of applying power to gliding that they forgot about the gliding. But Jean-Marie Le Bris remembered.

Le Bris was a sea captain who came from Brittany in the northwest of France. Like the Ancient Mariner, he knew his albatrosses. He watched them and puzzled over their

ability to soar endlessly without flapping their wings. He wanted to do the same. He watched with irritation the easy flights of these birds, who knew so much less than he, yet who had somehow been born with the mystery of flight revealed to them.

Le Bris was a good, hard, practical man — as anyone would be whose mind and body had been weathered by long years at sea. He caught an albatross, killed it, and took one of its wings. Of his resulting experiment he made this proud remark: "I took the wing of the albatross and spread it to the breeze, and lo! in spite of me it drew forward into the wind; notwithstanding my resistance it tended to rise. Thus I had discovered the secret of the bird! I comprehended the whole mystery of flight."

These are brave words. No one would feel safe in uttering them to-day. Nevertheless Jean-Marie Le Bris comprehended a great deal, as his very first experiments showed. He set about to build himself an artificial albatross. It had a wing span of 23 feet and a wing surface of 220 square feet. The body was boat-shaped, $13\frac{1}{2}$ feet long, with a maximum width of four feet, and made of cloth stretched over a wooden frame. The angle which the wing made with the horizontal could be controlled by pulleys and levers. In its final ready-to-fly condition it weighed 92 pounds.

Le Bris was close to fifty when he built his albatross, and at an age when many men are beginning to think of pensions, retirements, and lives of ease. None of these things interested the old captain. After a life at sea he wanted only a new ocean to sail — the ocean which, as Sir George Cayley had pointed out, reached to every man's door.

The village of Douarnenez saw his first experiments. The

year was 1855. Sir George Cayley had only two years more of life. Henson had vanished in Texas. Stringfellow had for the time being lost his interest in aviation. Coxwell had not yet made his amazing balloon altitude record. John Wise still had his ambitions of crossing the Atlantic in speed and safety. And on a Sunday morning, when a twelve-mile breeze was blowing, Jean-Marie Le Bris and his albatross made their way toward a clearing in a trundling cart.

Once in position, Le Bris and his helpers unshipped the albatross and fastened it by a rope to the back rail of the cart. Le Bris climbed into the car of his glider and seated himself at the levers which altered the wing angle. The strange procession started off again, with attendants walking on each side and holding the wing tips steady. Le Bris kept his hand impatiently upon the rope which fastened the albatross to the cart. One hard jerk and the knot would slip; the albatross would be free to do what it liked.

The plodding horse followed a turn in the road which brought the glider full into the wind. Le Bris shouted, and the men let go. The driver in the cart larruped his horse wildly. Le Bris pulled sharp on the lever which raised the front edges of the wings, and the albatross skimmed upward into the air. The horse, relieved of the load which the air had now taken on, went from a trot to a gallop under the profane lashings of the driver. Le Bris pulled his knot and the albatross came clear.

But not quite as clear as had been planned. First the connecting rope caught on a nail, and the soaring plane yanked the back rail out of the cart. To the exultant Le Bris, this was a minor catastrophe. The albatross was soaring upward with perfect stability, and in a brief few minutes had

reached an altitude of three hundred feet and had traveled one eighth of a mile. Never had there been a prouder sailor of the new ocean.

But there had been another little accident connected with the take-off. The connecting rope had not only caught on a nail — it had afterward caught on the driver of the cart, who somehow, in the brief flash of a second, had got himself inextricably tangled up in it like Laocoön with the serpents. And when Le Bris and the albatross soared proudly into the air, the driver of the cart, at the end of a rope some twenty feet below, soared much less proudly with them.

From his seat in the car Le Bris could see in every direction except the one in which the driver most wanted him to see. Nor was the driver's angle of suspension particularly conducive to measured or even to effective utterance. He managed in a few moments to get enough wind for shouting. He bellowed at the top of his lungs. The situation slowly began to dawn on the rider of the albatross, and when the truth burst upon him it caused him some impatience. He was royally enjoying himself and had set out to prove that he could stay aloft for two hours. For a moment pride and compassion warred within him. Then he changed his wing angles and began the descent. Compassion had won.

With the albatross about thirty feet aloft, the driver's feet struck ground. He disentangled himself in an instant and went tearing after his horse, who, so swiftly relieved of supervision, had gone ways that seemed good to him. Then fate played one of her smallest and meanest tricks on Jean-Marie Le Bris. By all the standards, a man who makes a noble and self-sacrificing gesture for a friend should himself reach some graceful conclusion. Fate did not so arrange it to-day.

The albatross, without the suspended weight of the cart driver, lost its stability. Le Bris worked frantically with his lever to restore it, but the albatross swooped suddenly downward and Le Bris landed with a splintering crash. It is never any joke to fall thirty feet, particularly when you have entered your fiftieth year. But fate was only intent on humiliating Le Bris, not on injuring him physically. He got out of his shattered albatross, jarred from truck to keelson, purple with rage, but physically whole. The albatross had lost a wing, but both it and its builder-navigator had achieved a flight of amazing, if too brief, satisfaction.

Now Le Bris, like Sir George Cayley before him, found himself confronted with the old servant problem. Cart drivers were no longer interested in helping further his researches.

Nevertheless Le Bris was quick to try again. He repaired the broken wing of his albatross and assembled it in the bottom of a quarry, dug out from one side like a sand pit. Then he hoisted the plane by a derrick erected upon the edge of the depression. When the wind blew from the right quarter, he climbed aboard, adjusted his levers, let go the restraining hooks which held him back, and glided off over the quarry — the bottom being one hundred feet below him.

Le Bris knew his winds — but they were the winds of the sea. He did not know that in such a location as a quarry or a sand pit it was inevitable that he should encounter a sudden upward rush of air. One of these erratic gusts struck the albatross. Stability gone, it swooped to the bottom of the sand pit. This time Le Bris's accident was neither lucky nor funny. He was lifted out of the complete wreckage of his glider with a broken leg.

The leg knitted soon, but something had also happened to his courage, and his courage did not knit. He built a second albatross, but never flew in it; never, in fact, flew again. His second albatross he sent up with ballast. It glided well, but it carried no human brain aboard it and consequently reached only half the altitude of the first one on that happy day when a younger Le Bris had thought to soar for some two hours.

By this time Le Bris had spent every cent he possessed in the building and flying of his models. In 1867, twelve years after his first experiments, a public subscription raised at Brest enabled him to live and go on with his work. His second albatross, equipped with a movable counterweight to help equilibrium, was publicly exhibited and came to much attention. But when he tried to fly it, he encountered the same jeering hostility for which crowds are always noted and which had already driven William Henson into oblivion. The wind, that day, when Le Bris sent up his second albatross from the levee at the port of Brest, was not strong enough for a real performance. The glider went up thirty or forty feet, flew perhaps twice that distance, and came down again safely. But this was not enough for the crowd, which was anxious to see something highly spectacular. Comment was vicious and hostile, and Le Bris never again consented to perform a public experiment.

After this, bad luck consistently dogged him. With ballast, he once sent the second albatross up six hundred feet, tethered to the ground by a light line. Then a gust caught it, plunged it to the earth, and converted it in an instant to a few scraps of stick and shreds of linen. Le Bris insisted that had he been aboard it he could, by adjustment of his wing surfaces,

have prevented that crash. Anyone, insisted his friends, who had been aboard such a wild contraption would have been instantly killed. He was a crack-brained experimenter, they decided, and promptly forsook him. With them went the last remnants of aeronautical courage that Jean-Marie Le Bris possessed. He cleared away the wreckage of his second albatross and never tried again.

Yet this old man, at the age of sixty-two, served with honor in the Franco-Prussian War and came out at its conclusion to become a special constable in his native town. It was only then, after surviving the perils of the sea, the dangers of the air, and the horrors of a bloody war, that the end came to Jean-Marie Le Bris. In 1872, he was ambushed and killed by a gang of ruffians.

Le Bris was the third man in history to experiment successfully with gliding flight. Besnier, jumping from his garret, was the first. Sir George Cayley, persuading his unwilling coachman aloft, was the second. Le Bris, with his involuntary ballast of cart driver dangling at the end of a rope, was the third, and the most successful of all.

In the same year that Jean-Marie Le Bris had killed his albatross, held its wing in the wind, and " comprehended the whole mystery of flight," another heavier-than-air enthusiast had begun his rise toward prominence in France. His real name was Félix Tournachon, but he called himself for his greater convenience, and ours, Félix Nadar.

Nadar was a photographer — a disciple of Daguerre. He was the first man ever to take photographs from a captive balloon. He soon turned an active mind and an immense energy toward thoughts of flight itself. Then he met Gabriel de la Landelle and Ponton d'Amécourt — the latter deeply

immersed in building an experimental steam helicopter. The three founded the Société d'Autolocomotion Aérienne in 1862. But this was not sufficiently resounding. Soon after 1862 the name was changed to La Société d'Encouragement pour la Locomotion Aérienne au moyen d'Appareils plus lourds que l'Air.

Fortunately De la Landelle had a happy flash of inspiration. He coined the word *aviation,* and the name of the organization which he and his two friends had begun was changed to La Société d'Aviation.

It was then that Nadar showed himself to be an economic genius as well as a fine enthusiast and a skillful experimenter. Interest in lighter-than-air craft was still keen; the balloon could easily be made to pay its own way — far more than the struggling glider could hope to do. So Nadar constructed a huge balloon called Le Géant and set to work to use it to raise funds for the heavier-than-air machines which were his real enthusiasm.

The Giant Balloon lived a troubled life, though its start was auspicious. It was exhibited, like so many other aeronautical novelties, at the Crystal Palace. Its diameter was close to 100 feet. Its total height, including gallery, was 196 feet — just 45 less than the height of the towers of Notre Dame Cathedral on the Île de la Cité in Paris. Fully inflated, it had a lifting power of four and a half tons.

For the sake of safety, this colossus was constructed as a double balloon; that is, it had two complete and separate gas envelopes, one inside the other. The theory was the same as that of the double bottom for ships. Should anything puncture one skin there was still another to preserve buoyancy. The large and elaborate car had two floors. There was a

cabin for the captain and three-decker beds for the passengers. There was a photographic room, a lavatory, and a printing press.

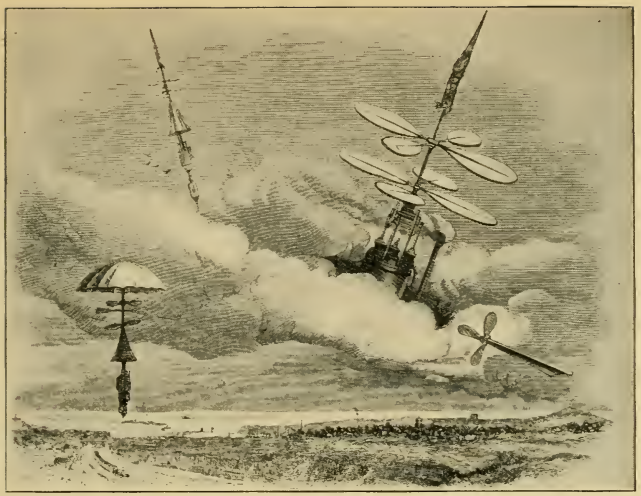
The first ascent was made on October 4, 1863, from the Champ de Mars. The ghosts of Professor Charles and the brothers Robert must have been there; and the ghosts, too, of Louis XVI and of Marie Antoinette — all gone now to their deaths, some quiet, some violent, since the day eighty years before when the first Charlière had "risen majestically in a shower of rain" from that selfsame spot. The *Morning Post* of that day suggested that 100,000 people had gathered to see Le Géant go up.

Driving through the Bois de Boulogne that morning was the Princess de la Tour d'Auvergne. Over the tops of the acacias and the horse-chestnuts, she saw the giant balloon swaying and straining at its ground ropes. "Drive there," said the Princess, regally, and pointed to it.

She was on the field in a few moments, and asked of Nadar, who was the captain of the voyage, that she be taken along. She was. As companion nobles she had the Prince de Sayn-Wittgenstein and the Count de St. Martin. The other twelve persons in the car were commoners.

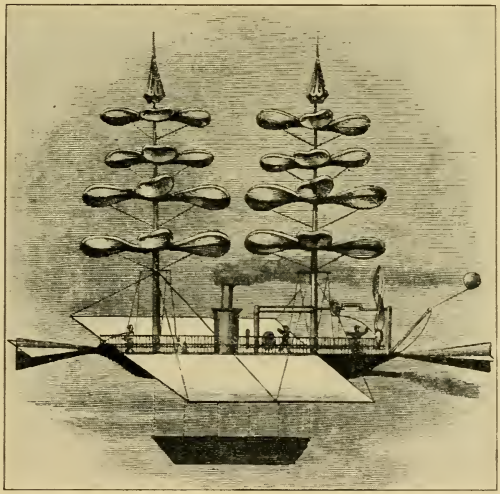
The balloon rose fifteen hundred metres — a little less than a mile. At nine o'clock that evening it landed at Barcy, near Meaux, and shook up its occupants in the process. None the less, the passengers had been charged a handsome fee for their privilege and Nadar had advanced his ambitious plans for heavier-than-air experiment.

There were twelve rules for the conduct of passengers on the giant balloon. These were among them: —



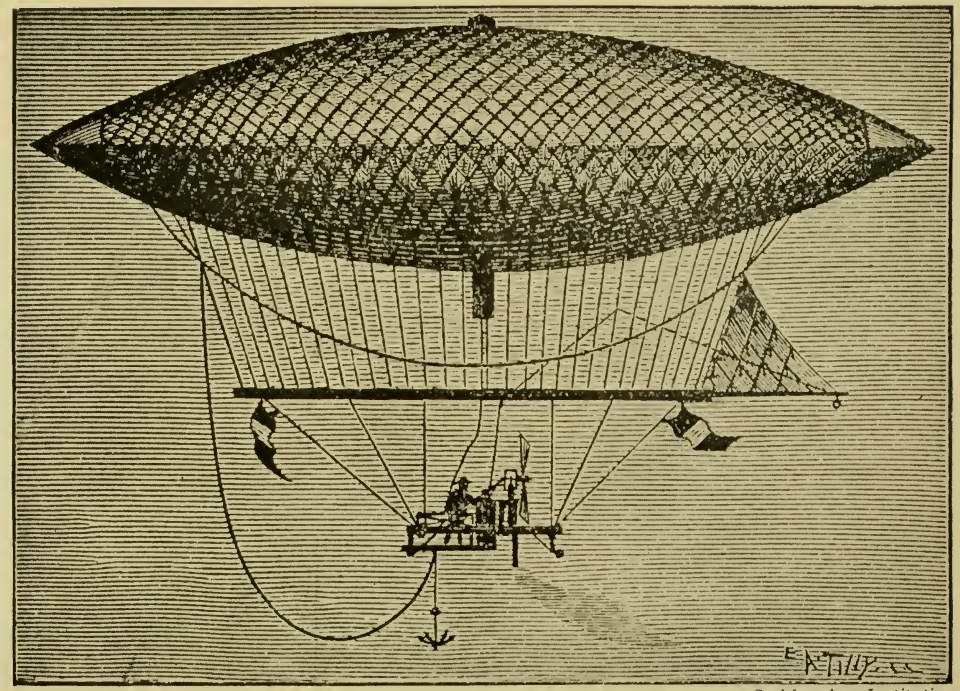
NADAR'S IDEA

This Was the Invention of a Photographer (*Page 104*)



DE LA LANDELLE'S IDEA

Like Nadar's, It Remained an Idea
(*Page 105*)



Smithsonian Institution

THE FIRST DIRIGIBLE

It Was Henri Giffard Who First Succeeded in Steering a Balloon (*Page 117*)

From the departure to the return there shall be only one command, that of the Captain. That command shall be absolute.

Every passenger declares, at the time of ascending, that he carries with him no inflammable materials.

Silence must be absolutely observed when ordered by the Captain.

All gambling is expressly prohibited.

It is absolutely forbidden for any traveler to throw overboard ballast or any packet whatever.

No passenger can carry up with him luggage exceeding thirty pounds in weight and occupying more space than an ordinary traveling bag.

Except in very rare cases, of which the Captain shall be judge, it is absolutely forbidden to smoke on board, or on land within the vicinity of the balloon.

Two weeks later came the next ascents of Le Géant. This time she carried thirty-two passengers on a short ascent and nine on a longer one. The Emperor Napoleon III was an observer. When The Giant, which seems to have had a fondness for rough landings, finally came down near Eystrup, in Hanover, Germany, it did so with such violence that five passengers were injured; three seriously and two slightly. With anchors broken and gas dwindling, The Giant had dragged through trees and bushes for several hours. Nadar himself was among the casualties, both legs being broken.

The result, none the less, was a marked increase of interest in mechanical flight. Nadar, De la Landelle, and D'Amécourt had funds to work with. Nadar started the periodical, *L'Aéronaute*. He worked like a demon, too, in the design of engine-driven gliders. His model had one engine driving two four-bladed vertical screws in opposite directions — the whole apparatus capped by a parachute above it. During

1863 the three friends all built models which rose successfully from the ground and carried small weights.

When the Franco-Prussian War flamed out in 1870, Nadar was active in forming the Ballon Poste. This was a civil, not a military organization, whose sole desire was to get mail out of Paris while the city was under siege. This plan worked splendidly. The trouble was that no member of the Ballon Poste, once he got outside of Paris with the mail, could ever hope to get back in again. The Prussians and the variable winds of northern France saw to that.

It was largely lack of directional control which kept the balloon from being of any particular service to the strategists of either the French or the Prussian army. At one time Nadar, relying on a favorable wind, ascended from Tours, bound for Paris. Close to the city, and ten thousand feet in the air, he sighted another balloon, and promptly displayed the French flag. The other balloon did likewise. The wind brought the two close together, and when they were within rifle range of each other the second balloon suddenly broke out the German flag. There ensued then the first aerial battle in history. Nadar's rifle aim was the better; he was victorious and succeeded in landing within Paris, to the acclaim of the thousands who had watched this first battle in the skies.

But the Ballon Poste was seldom so successful. On November 24, 1870, two balloons left Paris for Tours. They encountered a violent gale and snowstorm, and after thirteen hours of travel at a speed they could not possibly estimate, and in what direction they knew not, they landed. Were they, they enquired, in the vicinity of Tours? They were not. They had traveled six hundred miles north and were in Norway.

And yet, directional control was close at hand. If France had been more appreciative of the genius of Henri Giffard, the Ballon Poste might have been more successful — and even the Franco-Prussian War less of a disaster for the mother country of aerostation.

XII

THE BEGINNINGS OF CONTROL

To Montgolfier the Invention 's due,
Unfinished as it lies,
But his will be the glory who
Direction's art supplies.
— Anonymous verse published in 1786.

Hundreds of attempts had been made to control the flight of balloons, starting almost the very day that the States of Vivarais had assembled to see the brothers Montgolfier send up their first aerostat. For the very first suggestion we are indebted to Marey Monge — the wild man of aerostation. It was he, you will remember, who spent twenty-five thousand francs in an attempt to build one of Francis Lana's vacuum balloons as late as the year 1845. This was comparative sanity for him. In 1783, the heavy wine of the new aerostation had gone badly to his head. He was riotously intoxicated by it. His first proposal was that twenty-five balloons should be strung together like beads on a necklace. There would be an aeronaut in the car of each. Controlled by their aeronauts, each balloon would ascend in its turn, and in its turn descend, so that the chain of aerostats would wriggle forward through the air like a water snake looping through the surface of a creek.

The next two aeronauts to attempt control were Blanchard

and Lunardi, whose efforts have already been chronicled. Likewise with the brothers Robert and the Duke of Chartres, whose experiments took place in the year 1784. Their parasol oars served no purpose.

In July of this exciting year, the Abbé Molan had a spectacular idea. In the side of his Montgolfière he would make a hole. The air, heated by the fire in the gallery, would, as always, strain upward inside the sac, but now, thought the Abbé, a certain amount of it would be driven violently out through the hole, and the balloon would thus be driven forward. For a comparison in principle, we can make two illustrations which the Abbé, in 1784, was not privileged to know about. Steam drives a reaction turbine on this principle; water rushing through a nozzle tends to force a hose backward for the same reason.

Theory, then, sided with the Abbé, which was unusual enough for those days. In practice, however, this reaction jet would have been far too feeble to give any velocity to the large mass of a Montgolfière, even if it had had to work against nothing but the air resistance of a calm. Add a breeze to that, and no one would ever have known that the Abbé's balloon was trying to go anywhere. But the Abbé never had this bitter discovery forced upon him. His Montgolfière caught fire, and he gave up science.

The brilliant General Meusnier comes next. His balloon was to be 260 feet long and was to carry three propellers worked by hand power. Of course this design was entirely impracticable. But remember that the late eighteenth century had only the most modest ideas of power. A horse was still the ultimate in strength; the steam engine was still almost too recent to be anything but a novelty, and even it was a feeble

instrument for its weight. We know now that a balloon of Meusnier's design and with 60,000 cubic feet gas capacity would require at least thirty horsepower applied at every propeller for satisfactory performance.

In 1786 a gentleman by the name of Uncles announced that he had built a balloon to be drawn by " four harnessed eagles, perfectly tame, and capable of flying in every direction at their master's will." He further declared that he would give the world the benefit of his efforts and stage a public demonstration. That was in April. In May he deferred his experiment on the ground of unsettled weather. The birds, however, he said, were " well practised." There were further postponements, and the month of August came without any demonstrations by the harnessed eagles. Before the month had passed, the eagles did make their appearance at Ranelagh. Uncles may have been an excellent animal trainer; with inanimate objects he was less successful. He was never even able to get his balloon inflated, and the ambition and practice of his eagles, no matter how great, went for nothing.

By now, aerostatic experimenters began to fall under the spell of sanity which Sir George Cayley was busily spreading. In spite of him, there continued to be outbursts of delirium. In 1825, E. C. Genêt, French scientist, coming to the realization that manual power would always be inadequate for any kind of flight, suggested his *ballon à chevaux*. This was to be an elongated balloon — 152 feet from tip to tip. Below and amidships, it was to carry a suspended platform, which contained a treadmill in its centre. On this treadmill two proud horses with flying manes and held firm at the rump and withers would maintain a spirited gallop, thus, through gearing, driving two large paddle wheels. This invention,

like so many of its predecessors, remained unhappily on paper. It would have been a great treat to see.

Nine years later Count Lennox, a French colonel of infantry, built his aerial ship. This was called the Eagle, " constructed for establishing direct communication between the capitals of Europe." The gas envelope was 160 feet long, 50 feet high, and 40 feet wide. A wooden car 75 feet long and 6 feet wide hung underneath. The gas envelope had a capacity of 200,000 cubic feet, and would thus, if filled with hydrogen, have provided a buoyancy of 10,000 pounds. The Eagle's carrying capacity was twenty-five persons, of whom seventeen were crew. The motive power was to come from four paddle-shaped flappers on each side of the envelope which were to be worked back and forth by hand like the fins of a fish. There was also a beaver-tailed rudder to control direction.

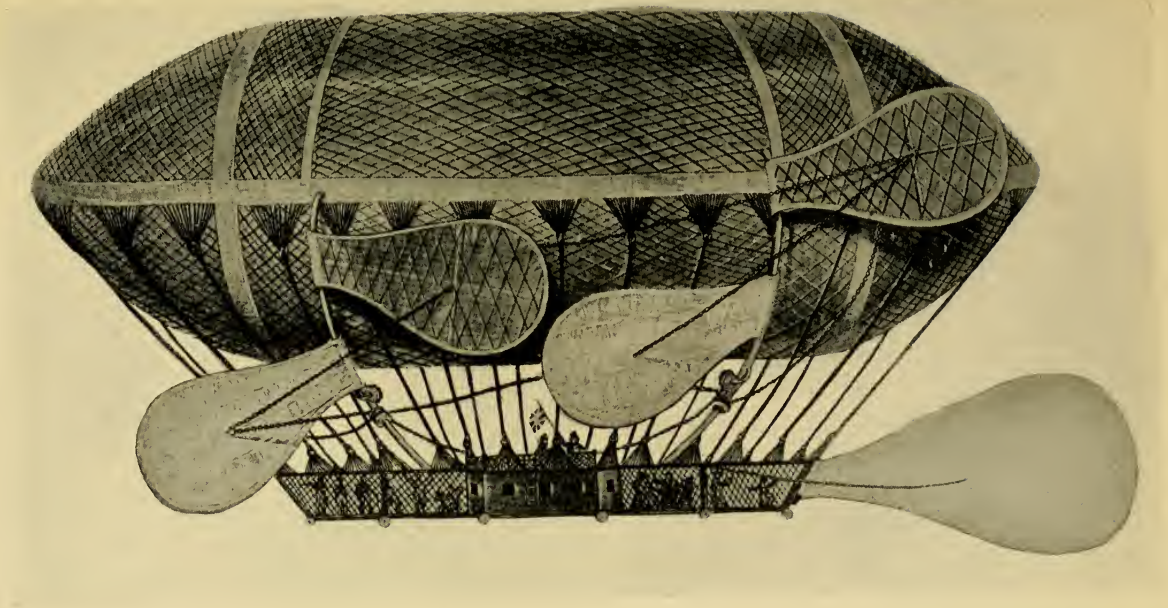
This propelling mechanism never had a chance to prove itself a failure. Disaster overtook the Eagle too soon. Before its first ascent, which was to have taken place in August 1834 from that favorite aerostatic field, the Champ de Mars, the netting of the Eagle broke and the inflated gas envelope escaped, to burst a few moments later in mid-air. Count Lennox got no sympathy from his spectators. With the invariable viciousness of crowds, they rushed upon the wounded remains of the Eagle and trampled them into kindling.

However, Count Lennox was stout-hearted. He gave up his attempts to please the volatile French and, undiscouraged, went to London. There he met with more encouragement. He built a second ship and once again called it the Eagle. This London Eagle was for some time exhibited at Kensington in the " dockyard " of the so-called European Aeronauti-

cal Society, which, one suspects, was just another name for Count Lennox. The exhibition opened in June and ran until August, 1835. Shortly thereafter it was moved to the Vauxhall Gardens, from which, only one year later, the Messrs. Green, Mason, and Hollond were to make their famous flight to the Duchy of Nassau. An ascent for the Eagle was promised within a month, but when the exhibition closed in October this flying ship with the fins of a fish remained as earth-bound as ever. Count Lennox's ambitions had seeped slowly away, and no ascent was ever made.

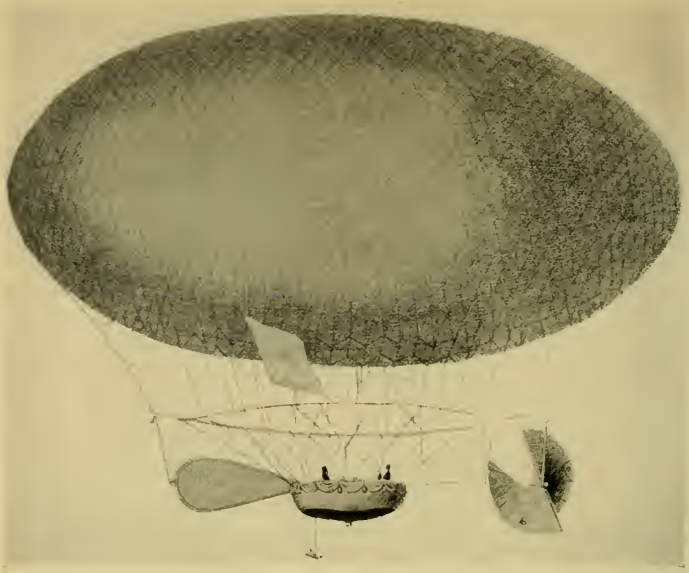
In 1843, seven years after he had been a passenger in the Great Nassau Balloon, Monck Mason achieved one more distinction. He built a working model of a dirigible that really succeeded. There was, he thought, "but little prospect of ever attaining" complete success in navigating balloons. None the less, his large egg-shaped working model, 44 feet long and of 320 cubic feet gas capacity, did actually drive itself along, with the aid of clockwork, at a speed of about six miles per hour. The propeller was a real Archimedean screw — not the mere section of it which we use to-day. In other words, this model dirigible was driven by a mechanism at the rear which looked like the business part of a meat grinder, operating at high speed. The model was exhibited at the Royal Adelaide Gallery in the Strand, but the pessimistic Mason, convinced that there was "but little prospect" of success, had no enthusiasm for pushing his design to the test of a full-scale machine.

By now, success was coming close to hand — was, in fact, much closer than anyone realized. If Pierre Jullien, a French clock maker, had had sufficient money to build a full-scale machine, the chances are good that he would have been the



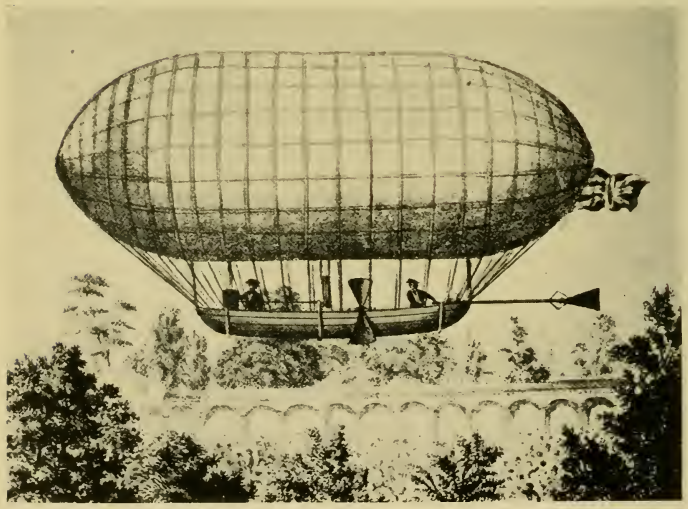
LENNOX'S EAGLE

An Unhappy Victim of the Mob (*Page 113*)



THE MODEL DIRIGIBLE OF MONCK MASON

It Discouraged Its Inventor (*Page 114*)



THE LOCOMOTIVE BALLOON

Invention of the Englishman, Hugh Bell (*Page 115*)

man to reap the glory for supplying direction's art to Montgolfier's invention. At the Hippodrome in Paris, in 1850, Jullien experimented with a model airship of elongated, stream-line form, carrying propellers, rotated by clockwork drive, on either side of the centre line. This model had both rudders and elevators, — something new to find in combination, — and Jullien called it, with real, if accidental, foresight, Le Précurseur.

But his money was insufficient. As it was, an Englishman attained the distinction, in the language of the London *Times,* of having " achieved a new discovery in the Science of Aerostation — that of controlling, directing, or steering a balloon." That was how the *Times* reported the first flight, in 1850, of the " patent locomotive balloon " of Hugh Bell, an English physician.

It was Bell, then, who made the first attempt in England to apply the aerial screw — invented by Leonardo da Vinci nearly four hundred years before — to control the flight of a dirigible balloon. Bell was diligent with experiments on working models. When he built his actual machine, he made it 50 feet long, 22 feet in diameter, and with conical ends. The gas envelope had a capacity of 15,000 cubic feet, which supplied a buoyancy, when filled with coal gas, of between 500 and 600 pounds. A canoe-shaped car was suspended under it, which was to have had a propeller on each side, but for some forgotten reason the trial was made with only one propeller. Here, in 1850, was every element necessary for a successful dirigible, except the one thing without which all designers were struggling hopelessly in the dark — a light and efficient source of power.

The first trial of a locomotive balloon came in 1850 at the

Phœnix Gas Works, Kensington Oval. Bell went up alone in his canoe-shaped car. The ascent was quite satisfactory, but the actual effect of the propeller seemed, for all the report of the London *Times,* to be somewhat in doubt. Probably it did have some slight directional effect, and Bell's experiment would have been much more conclusive and satisfactory if he had deigned to take an assistant with him. Imagine a dirigible, even a small one of to-day, managed by one man. Then, to confuse the result, a sufficient wind had sprung up to drift the locomotive balloon thirty miles in the space of ninety minutes.

This first exhibition had been private. From the veteran Vauxhall Gardens a public one was held two months later, in July. This time, Bell sweated at the crank of his propeller quite in vain. The wind was too strong for him and the screw had no noticeable effect.

In the next year Henri Giffard brought the study of directional control into the domain of hard common sense. Giffard was a brilliant engineer. He had been the inventor of that indispensable accessory to the locomotive, the steam injector, from which he made a fortune which was later spent to do his share for the advancement of aviation.

In 1851, when he was only twenty-six years old, he succeeded in constructing a small, light-weight, and efficient steam engine, with the idea that it would serve as the power plant for a lighter-than-air machine. In 1852 he built a full-scale dirigible in the now-accepted elongated form with pointed ends. It was 144 feet long — almost three times as long as Dr. Hugh Bell's locomotive balloon. It was 44 feet in diameter at the centre and had 88,000 cubic feet of gas capacity.

Twenty feet below the envelope, Giffard suspended his car, in which he had placed his small, one-cylinder, three-horse-power engine and its boiler. Geared to the engine was a three-bladed propeller designed to run at 110 revolutions per minute.

On September 24, 1852, Giffard ascended from the Hippodrome, in Paris, the same site that had been chosen by Pierre Jullien, the clock maker. The breeze was light; Giffard headed his fragile dirigible into it and succeeded, for all the dreadful hazard of the combination of an inflammable gas and a fire under his boiler to keep up steam, not only in preserving himself from an accident, but in ploughing clumsily through the air at a speed of about six miles per hour. This was just enough to give steerageway to the dirigible and to indicate finally beyond any shadow of doubt that after seventy years the balloon had been conquered, and that direction's art, no matter how feebly, had finally been forced upon the invention of the brothers Montgolfier — or, more properly, of Professor Charles.

Three years later Giffard built his second machine, increased in length and decreased in diameter over his first model. It was not so successful, and Giffard and a passenger narrowly escaped death when the gas envelope burst during descent. He went on, undeterred, with plans for a third machine. He proposed the incredible length of 1970 feet, and a capacity of 7,800,000 cubic feet — more than that of any dirigible that is contemplated even to-day. The expense proved too great, however, and plans were never carried out. Then the brilliant Giffard went blind, and in 1882 he died.

After this sober and successful venture, James Nye brought the comic spirit back into aerostation by his proposal in 1852

of a rocket balloon. This was to be a dirigible 337 feet long and driven by the reaction from rockets fired off in the rear of the machine once every seven seconds. Each rocket would, the proposer calculated, weigh some three pounds. For a two-hour trip, then, 1029 rockets would be necessary, with a total weight of about 3087 pounds. It is easy to see why, entirely beyond the damage to a few nervous systems more delicate than Nye's, the rocket balloon remained a strictly theoretical machine. Even neglecting the problem of weight, the rockets and the coal gas or hydrogen would have been none too harmonious.

It was upon this foundation, shaky and insecure except for the genius of Henri Giffard, that Dupuy de Lôme built. His name looms large in aeronautics, yet aeronautics was never for him more than an avocation. His true profession was naval architecture. He was Chief Constructor of the French Navy and one of the great warship designers of all times. It was he who for the first time in history put an armor belt on a warship. She was the Gloire, launched in 1859 with 4 ¾-inch iron plates completely girdling her wooden hull. British Navy men sneered at this freak, and in their hearts were frightened.

It was the Franco-Prussian War which first turned De Lôme's thoughts toward aerostation. Paris was under siege. The Ballon Poste, which Nadar had been so active in forming, had been getting out of Paris in balloons with remarkable ease; but neither they nor anyone else had much chance of getting back in again. De Lôme set to work desperately on a dirigible in which the direction of flight could be controlled. But Paris fell, and the armies of Count von Moltke marched in before De Lôme could work out any plan.

Two years later France had recuperated enough from defeat to commission Dupuy de Lôme to build a dirigible. On the principles of his predecessor, Giffard, he built one, 108 feet long and 47 feet in diameter. De Lôme also devised a new triangular form of suspension for the car.

Unlike Giffard, De Lôme, whose concern had always been more with hulls than with engines, did not attempt to power his craft by artificial means. His four-bladed propeller was worked by a windlass and eight men, yet even with this rudimentary engine his dirigible achieved results which were very similar to those of Giffard. He demonstrated that a dirigible could alter its course as much as ten to twelve degrees away from the direction of the wind. A trial flight from Fort Vincennes, in February 1872, ended in a safe landing at Mondécourt.

If De Lôme had had available a satisfactory source of power, he would have made a showing unquestionably as satisfactory as did Santos-Dumont over a quarter of a century later. His genius for ship design had provided all the principal features which the modern dirigible incorporates to-day. The systems of control and stability were similar. So was the suspension system for the car. A ballonet and blower had, for one of the first times since the experiment of the brothers Charles and the Duke de Chartres, been satisfactorily applied. And De Lôme had developed a two-ply rubberized and doped fabric strikingly similar to that in use to-day.

About the same year as Dupuy de Lôme's triumph, the German engineer, Paul Haenlein, working at Brünn, developed a cylindrical balloon to be driven by a four-cylinder Lenoir five-horsepower engine, using gas taken from the sustaining envelope as fuel. This engine drove two four-bladed propellers.

In trials held in December 1872, the balloon showed perceptible but not enthusiastic symptoms of control. Haenlein worked for the next twenty years on an improved design, and in the course of his researches made one proposal which is incorporated into modern dirigible design. The modern separate "power car" was Paul Haenlein's contribution to aeronautics — and his craft was the direct ancestor of the present "semi-rigid" dirigible.

Eleven years went by before any further experiments brought results worth recording. But in 1883 the brothers Gaston and Albert Tissandier built a 92-foot dirigible with 37,500 cubic feet capacity, much similar to that of De Lôme, but supplied with energy from a 1½-horsepower Siemens electric motor. Current to drive it came from twenty-four wet batteries made of potassium dichromate and sulphuric acid. With a crew of three, the brothers gave their craft a trial at Auteuil on October 8, 1883, but the wind made their small, weak, and cumbersome motor ineffective. A second test, conducted a year later, was scarcely more satisfactory. They spent ten thousand dollars and then gave up, discouraged.

One year later their idea was taken up by the French Army officers, Charles Renard and A. C. Krebs, who were given a grant of forty thousand dollars by the government. They improved upon the Tissandier design and used an 8½-horsepower electric motor with their torpedo-shaped dirigible called La France. It was 165 feet long, had a maximum diameter of 27 feet, a capacity of 66,000 cubic feet, and a tractor-type propeller with the enormous diameter of 23 feet. A sliding weight preserved horizontal stability.

A trial of La France from Chalais-Meudon, on August 9, 1884, was immediately, startlingly, riotously, and completely

successful. At 14½ miles per hour it made a five-mile circular flight. For the first time in all history an airship set out on a voyage and returned to its starting point. Five times Renard and Krebs demonstrated their triumph; only twice did they fail.

And triumph enough it was. The idea of aerial control which men had been pursuing now for one hundred years through the twisting caverns of disappointment, misunderstanding, and confusion had finally been chased out into the clear light of day for all onlookers to see. Renard and Krebs were proud men, and with justification, even though their clumsy and overweight power plant had created another problem to be solved. Airships could now obviously be controlled. But no longer, because of the weight of their engines, could they carry any but a skeleton crew, nor could they carry any passengers or freight whatever.

And so the balloon, relieved of one disability, fell immediately into another. There is nothing further significant in its history for the next fifteen years. Unknowingly, aerostation was in the midst of a stage wait; the star performer, the petrol motor, was overdue and missing.

XIII

A VISION OF SUCCESS

THROUGHOUT the same years that Renard and Krebs, Dupuy de Lôme, and Henri Giffard were working to make the flighty balloon submit itself to some sort of control, other men were struggling with heavier-than-air machines along lines that had been begun by Sir George Cayley and by Henson and Stringfellow. Among the most gifted of these was a young lad who was only seven years old when Sir George Cayley, the great father of British aerodynamics, died.

Alphonse Pénaud had wanted, as a boy, to enter the French navy. Doctors rose to bar his way. His health was delicate; he could not pass the searching physical examination. Then, as if his health had not done enough for him, he came down with a disease of the hip joint and was forced to travel about on crutches.

Barred from a normal, healthy, out-of-door life, he had plenty of time for reading and contemplation. One day he came upon an article ridiculing man's presumptuous attempts to fly. Thereupon, although he knew nothing about aviation, Alphonse Pénaud became very angry. Impatience with glib people full of plausible reasons why something can't be done is always a sign of intellectual vigor. Pénaud showed it early. He was still a boy when he read that article.

Pénaud began to think out aeronautical problems for himself. After a time, he felt sure enough of his principles to

design small models. He applied to his gliders a new means of motive power, one that after almost sixty years remains unchallenged for its lightness and efficiency and is still in use on almost every model plane to-day — the elastic band.

This lad came to the study of aviation without any preconceived ideas. Some men were working on helicopters. Others were quite certain that the imitation of nature would bring the first success and busied themselves with flapping-wing models. And still others followed Cayley, Henson, and Stringfellow, the disciples of the rigid wing. Pénaud looked about him and decided that he would try all three.

For his first model, he built a helicopter. It had two sets of revolving wings, placed one above the other, driven by rubber-band motors, and rotating in opposite directions. It still remains by all odds the best thing of its kind. It would rise fifty feet into the air, and on its best flight made a record at which toy helicopters have shot ever since — twenty-six seconds of continuous performance.

In 1871 Pénaud built his first rigid-wing model. No one before had ever surpassed him in the thoroughness with which he worked out every problem in equilibrium. He guessed at nothing; he had mathematical justification for everything he did. The model resembled a monoplane. Its wing spread was eighteen inches and its width four inches. It was driven by a two-bladed propeller eight inches in diameter. The centre of gravity of the model was slightly in front of the centre of the surface of the wings, for Pénaud had realized (without the benefit of any real aerodynamic data to tell him so) that the centre of pressure of the wings was near the forward edge. Then, too, he bent up the outer ends of the wings to produce lateral stability by what airplane designers

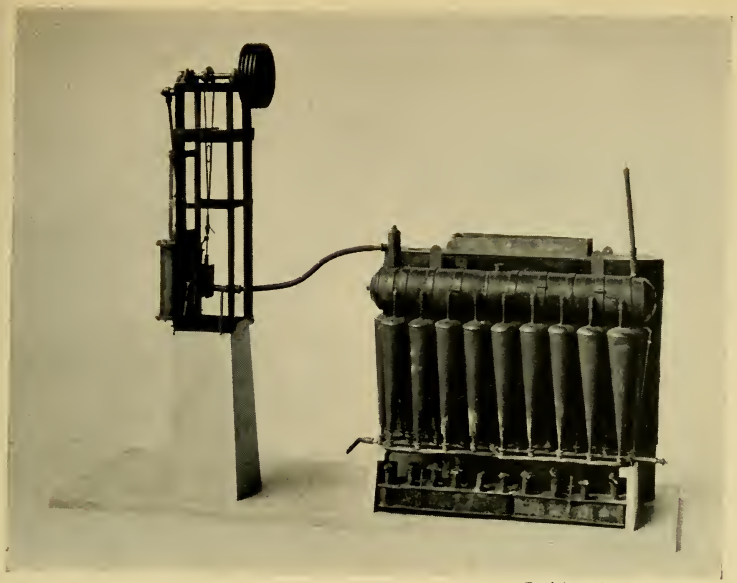
to-day would call a "dihedral angle." He provided also for longitudinal stability by placing a stabilizing surface at the rear, and setting it at an angle of eight degrees below the horizon of the main wing.

For all the completeness and exactness of his design, the model weighed only 0.56 ounces — including the weight of the rubber-band motor, which was 0.17 ounces. This model he publicly exhibited to a number of members of the Société de Navigation Aérienne in the Tuileries Gardens in August 1871.

The demonstration was a complete success. His model flew about in several successive circles and landed safely, after having gone 131 feet in 11 seconds with 240 turns of its propeller. Pénaud, warm and satisfied with the results of his model's test, never bothered to guess that he was really a great man and that the basic design of his little model set a standard from which aeronautic practice has never yet varied since that day.

But in 1872 he decided that he must experiment with a beating-wing model. Unlike its predecessors, this model would not rise from the ground, but when launched from the hand it would first descend about two feet and then fly some fifty feet in the next two seconds, rising finally to a point about eight or nine feet above the height of its take-off. Like every model which Pénaud ever designed, its equilibrium was perfect.

In 1876 he joined forces with Gauchot, a mechanician, in patenting a device intended to ascend with two men. It was a biplane with elliptically shaped wings, covered with varnished silk and stiffened by wire stays from two short struts, one on each side of the car.



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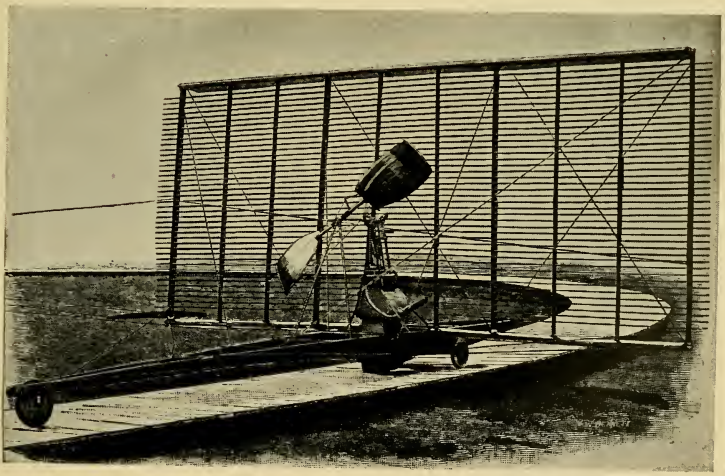
JOHN STRINGFELLOW'S AMAZING ENGINE

Once It Won a Prize of £100 (*Page 70*)



PHILLIPS'S FLYING MACHINE

An Early Triumph for Steam Power

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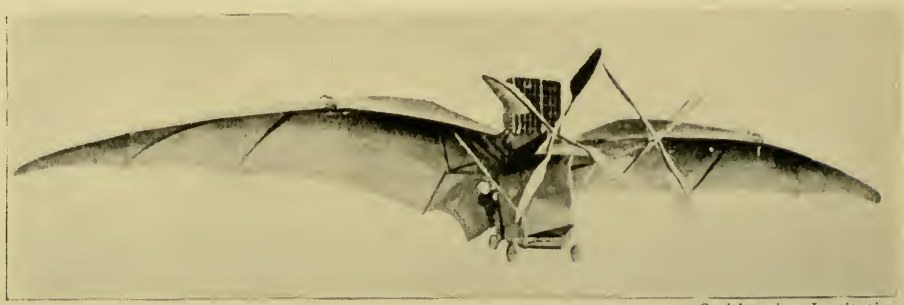
PENAUD'S ORNITHOPTER

A Flapping-Wing Model Driven by a Rubber-Band Motor (*Page 123*)



Smithsonian Institution

THE AVION OF CLÉMENT ADER

Did It Ever Fly? (*Page 159*)

The wing shape of this machine was curiously inferior to have come from the design of so thorough a student as Pénaud. Even so, the machine showed the most amazing variety of "modern improvements." Here is the list: (1) the wooden ribs were arranged with a slight dihedral angle; (2) the "aspect ratio" (the length of the wing divided by its width) was much more nearly what it should be than the ratio his contemporaries used; (3) the wing section was curved instead of flat; (4) the trailing edge of the wing was movable in flight (first appearance of the aileron); (5) the plane had a glass windshield; (6) it had a rudder and an elevator — and they were controlled by one lever (the first joy stick); (7) the plane had twin propellers; (8) it was so built that the centre of gravity in flight lay in the front fifth of the wings — once again showing how conclusively Pénaud knew that most of the lift came at the front edge, a truth of which even the Wright brothers for a time were unaware; (9) the plane was designed to make a speed of sixty miles per hour; (10) there was provision for four instruments — an anemometer, or wind-speed indicator, a compass, a level, and a pressure indicator to give altitude.

This amazingly thorough and forward-looking design completed, Pénaud and Gauchot began to cast about for funds with which to build it. Neither man had any experience, ability, or liking for the art of raising money. Pénaud discovered himself with most of his money gone and no more forthcoming, criticized and misrepresented on every hand. Obstacle after obstacle was thrown in his way. In 1880, his courage gone and his health finally broken, this young man — he was only thirty — who might, with a little greater toughness of the hide, have lived to become one of the greatest

scientific pioneers in the history of the modern world, placed a revolver against his temple and shot himself.

But the thirty short years of Pénaud's life were sufficient for him to write his name large in aeronautics. To him aeronautics is indebted for the invention of a plane table for plotting the course of balloons; for the guide-rope brake; for a delicate barometer for determining heights; for a tailless kite; and for a new type of internal-combustion engine. He also proposed a series of experiments on air resistance, and had he lived there seems little doubt that he would have acquired, as a by-product, the fame of being the first inventor of the motion picture — for he wanted to investigate the flight of models by means of "instantaneous photography." The pistol shot ended these brave schemes, and many another that had not yet had time to form in this wildly restless, strangely gloomy brain.

In contrast with Pénaud stands Hureau de Villeneuve. Pénaud lived only thirty years, and into ten of them packed almost everything there was to do in aeronautics; De Villeneuve worked steadily for twenty-five years on nothing but flapping-wing machines. His garret must have been a strange pigeon loft, for he built some three hundred of them.

After years of experimentation with model artificial birds, De Villeneuve built a man-sized one — fifty feet from tip to tip of wing and modeled after that unlovely mammal, the bat. This craft was unlike any other that had ever before made its appearance in the entire history of man's attempts to fly. Somewhere in the bowels of his bat, De Villeneuve placed a steam engine. So far, so good. The trick comes next: to reduce the weight of the power unit, De Villeneuve

left the boiler on the ground, connecting it to the engine with a short length of flexible hose.

It is perhaps just as well that the first test of this unique machine was private. De Villeneuve, very nervous at the idea of taking off in a machine of his own design, got in and flutteringly turned on his steam. He was rewarded by a thunderous flapping of his heavy hinged wings. The machine began to move in every conceivable direction except up. Finally, it went even in that direction for a few feet. The inventor was exultant but nervous. Suppose this lumbering bat should take the idea into its head to make a real soaring trip? This thought was altogether too terrifying. Before things could come to such a pass that the hose connecting the engine and boiler should separate somewhere, De Villeneuve shut off his steam. The madly gyrating wings stopped on the instant and the steam bat settled down to its nest again, raising a shower of dust and splinters. One wing had been broken. This flight was quite enough of a triumph for the inventor. On these laurels, and on the secretaryship of the French Aeronautical Association, he rested.

During these years, experimenters in England, France, Germany, and the United States had realized the correct basic principles of the airplane. What they lacked was a proper understanding of the problems of stability and a sufficiently light motor.

To the study of aeronautics Thomas Moy brought an excellent equipment. He was an engineer and a draftsman, an inventor and a patent agent. He was a strong advocate of mechanical flight and a staunch supporter of the British Aeronautical Society in the early days when all its members were thought insane. The chief value of his work lay in

his persistent demand that mechanical flight receive detailed, serious scientific study. He insisted, quite rightly, that high speeds were essential to heavier-than-air flight. His idea was that planes should travel at 150 miles per hour. In this he anticipated Samuel Pierpont Langley.

With justice, he was a great admirer of Henson and Stringfellow. During 1868, in collaboration with R. E. Schill, he worked on a steam engine and claimed to have reduced its weight to seven pounds per horsepower. In 1874 he built his "aerial steamer"—a large model which was tested on a circular track at the Crystal Palace in 1875. The model was tethered, so that it ran in a circle. From a board track it actually rose six inches clear of the ground, its three-horsepower engine lifting a total weight of 120 pounds. Moy, however, experienced the same difficulty as Stringfellow. The rush of wind, when the model got under way, invariably blew out the alcohol lamps under the boiler.

Subsequently, a gale wrecked his machine. He rebuilt it, but without much success. He had ambitions to build a 100-horsepower plane, but, lacking the money and finding himself involved in two lawsuits over his patents, he was forced to give up experiments. His later work was theoretical, but of much value.

For one hundred and ten years Europe was the cradle of aviation, and France led the development by an overwhelming margin. England, in spite of the genius of Sir George Cayley and the rugged pioneering of Henson and Stringfellow, ranked a rather poor second. Germany and Italy were nowhere. America had contributed only Rittenhouse, Hopkinson, Wilcox, and after a lapse of half a century, John Wise. Then, all of a sudden, Laurence Hargrave burst out in

one of the most unlikely quarters of the world — the antipodes of New South Wales.

No one better deserved to fly. Hargrave made with his own hands more than fifty model planes — each one a successful flier. Many other men were secretive and suspicious, but Hargrave published a frank and detailed record of everything he did, successful or not, knowing quite well that an exchange of ideas would hasten success. "Workers must root out the idea that by keeping the results of their labors to themselves a fortune will be assured to them," he said. "Patent fees are so much wasted money. The flying machine of the future will not be born fully fledged and capable of flight for one thousand miles or so. Like everything else, it must be evolved gradually. The first difficulty is to get a thing that will fly at all. When this is made, a full description should be published as an aid to others. Excellence of design and workmanship will always defy competition."

Hargrave decided that flapping wings and propellers were equally effective as means of propulsion. For himself he preferred the flapping wings. He had some amazing reasons for this preference. He thought that one advantage lay in the fact that any air currents produced by the upstroke would give a greater efficiency to the downstroke — which means that unknowingly he subscribed to the principle, which wrecks so many amateur engineers, that you can get something for nothing. Moreover, he thought that when steam engines came to be used the flapping wing would be greatly preferable, since one cylinder could push and pull both wings and the reciprocating motion of the steam engine could be applied directly to the wings, without bothering to convert this motion into a rotary one. And a flapping-wing mechanism

would produce no "variable listing moment" — that is to say, would entail no whirling mass of crankshaft and connecting rod to upset stability. As a crowning reason, he suggested that there would be less likelihood of damage to flapping wings than to a propeller when a plane landed. There is an easy logic to all this — but unfortunately the facts as he saw them represented only a small part of the truth.

Notwithstanding, one of Hargrave's first models, built in 1889, was driven by a propeller which he placed at the stern and powered by a rubber-band motor. This model weighed exactly two pounds and had a wing surface of $14\frac{1}{2}$ square feet. It flew 120 feet on 196 foot-pounds of energy. A preceding model, built with flapping wings and weighing almost exactly the same amount, had flown 270 feet, but used up 470 foot-pounds of energy in doing it — which should have indicated to Hargrave that his flapping-wing mechanism was less efficient than the propeller he so disesteemed.

One year later, in 1890, Hargrave tried compressed air, instead of clockwork or rubber bands. He built a model which flew for 368 feet on 870 foot-pounds of energy — a long and impressive flight for that day, and the first model flight of really notable length ever made on the flapping-wing principle. Once again, however, the flapping-wing model proved much less efficient than his earlier propeller-driven plane. This model had two sets of wings, one stationary for stability, another flapping to provide locomotion. There was almost fifteen square feet of stationary wing area; a tenth of that for flapping. A peculiar feature of this model was contrary to the best modern practice, for the wings were much deeper than their spread. His wing area would have supported a far greater weight if the wings had been turned around the

other way, but Hargrave arranged the wings to travel lengthwise in an attempt to give longitudinal stability to his model, not realizing that what it needed was a tail.

His compressed-air engine was a sturdy affair. Despite its diminutive size and inconsiderable weight, it worked at a pressure of 230 pounds per square inch — more than that of most locomotives to-day. The compressed air was stored in a tube 48¼ inches long and two inches in diameter, which served also as the backbone of the plane. To pack all this machinery into so delicate an apparatus that the entire plane weighed only two and a half pounds was a feat in model building which it would be difficult to excel to-day. Paper wings, as usual, supported the model. The busy little engine worked with a stroke of only one and a quarter inches inside a cylinder one and a half inches in diameter.

But, successful though his model flights were, Hargrave remained dissatisfied with his power plants, knowing quite well that neither rubber bands nor compressed air would ever be applied as motive power for large-scale machines. Eventually he became an advocate of steam, but not before he had spent a good deal of time and money in trying to develop an "explosion motor." This well-named machine was a sort of turbine, driven by the gases resulting from the explosion of a mixture of ammonium nitrate, charcoal, and sulphur. The same villainous triumvirate of chemicals is at the bottom of many fireworks. They give generously of noise and smells, but little else. Hargrave's attempts to harness the gas were failures — but from no lack of gas to harness.

In March of 1893, he journeyed from New South Wales to America and in Chicago attended a conference on aerial navigation. There he described his eighteenth model: a

steam-driven plane whose machinery weighed seven pounds and which could actually develop the excellent figure of 0.653 horsepower, or one horsepower for every 10.7 pounds of weight — a real approach to the mechanical efficiency which would permit men to fly. It was in Chicago also that Hargrave, as a valedictory, spoke words that should be cast in bronze and placed over the entrance to every laboratory of science: " The people of Sydney who can speak of my work without a smile are very scarce; it is doubtless the same with American workers. I know that success is dead sure to come, and therefore do not waste time and words in trying to convince unbelievers."

XIV

FLAPPING WINGS

The history of invention had very clearly shown by the beginning of the nineteenth century that any attempt to copy nature in the building of machines was apt to turn out disastrously. When practical men came to apply the steam engine to the old " steam carts " which went before the automobile and even the locomotive, they made no attempt to build them on the principle of the horse. But in the face of this convincing parallel a certain group of men seemed always to be quite convinced that man could achieve flight only through imitating birds and applying the steam or internal-combustion engine to flapping wings. This idea was not confined to cranks.

In the days before the very first linen and paper bag of the brothers Montgolfier rose at Annonay, all ideas of flight, whether by machines lighter or heavier than air, had been a welter of confusion. Naturally the success of these paper-making brothers renewed many wild hopes in the breasts of men who still cherished ideas like those of Johann Müller, the Friar de Gusman, and John Wilkins, Lord Bishop of Chester.

In 1784, not a year after the States of Vivarais had assembled to watch the Montgolfiers' aerostat, a fellow Frenchman, Gérard, reawakened the whole question of heavier-than-air flight. He either did not know or did not care about Leon-

ardo da Vinci's aerial screw, but suggested instead a machine which would land on feet equipped with springs, and would be propelled by two different means. The first would be that old favorite, the rocket principle, which makes use of the reaction from the discharge of gas due to an explosion. The second would be flapping wings, and to make matters more spectacular he would make the wings flap by using a gunpowder engine — an idea for power which, by the way, long preceded the steam engine and only recently, with another source of power, has come into prominence again in the rocket-propelled automobile of Germany.

As was just as well, the public had now given all its flighty devotion to the aerostatic machine. The principle, being entirely new, was immediately accepted as being also revolutionary and as eliminating forever the possibility that man needed ever to attempt flight in a machine heavier than air. But by 1843, when the public and the scientists, too, had become bewildered over the resistance of the balloon to directional control, men had a chance once again to rise up with the voices of prophets and say that there was something after all in the heavier-than-air machine. Thus it was that in 1843 a London physician named Miller brought out plans for an aerostat to be worked by manual power. In this he was following in the steps of the French locksmith, Besnier. Miller's machine weighed fifteen pounds and its oiled-silk wings spread out seventeen feet from tip to tip. As always, this brilliant design specified that the wings would be lifted through levers by the arms and kicked into the downstroke with the feet. Miller's manual aerostat had one supreme virtue: it seems to have been the last of its kind.

But another bird worshiper came along in 1864. He was

the French Count D'Esterno. In this year he patented a flying machine which had two flapping wings attached to the side of a small car. It had a fan-shaped bird's tail and it was built to conform to the "seven laws of flapping flight" of which, along with "eight laws of soaring flight," D'Esterno was the gifted author. And these were the seven laws: (1) an up-and-down action of wings; (2) forward or backward inclination of wings; (3) torsional or twisting motion of wings; (4) up-and-down oscillation of tail; (5) lateral displacement sidewise of tail; (6) torsion of tail; (7) movement of centre of gravity.

The seventh requirement was to be met by supplying the aeronaut with a sliding seat. You can hardly blame the aeronaut if he looked at this last gift a trifle wryly. He had, he might have been justified in thinking, quite enough to do already. But Count D'Esterno insisted that these first seven requirements were insufficient without a vital eighth — initial headway. There was no means prescribed for obtaining this.

Such an apparatus, to carry one man, would weigh about 330 pounds, so figured the Count. The beating, turning, twisting wings would have an area of two hundred and fifteen square feet. Crude drums and ropes would be used by the aeronaut to accomplish the seven different essential motions. The aeronaut certainly would have had enough to do to make a trap drummer seem slothful by comparison. In his admirably complete treatise the Count omitted only one specification: his source of power.

Even the credulous public of the nineteenth century did not take Count D'Esterno seriously. He was pretty generally laughed at as being on the lunatic fringe. Perhaps it

was this lack of sympathy which deterred him. In any event he never built his machine.

This is rather a pity. The machine was certainly crazy enough. But its inventor was a wealthy man. He could have afforded to spend great sums in the promotion of aviation. If he had built his first machine, only to find that it would rise no farther than could a lumbering brick cart, he might have revised his plans, and spent his money on less eccentric designs. For although his theoretical machine was preposterous, he was unquestionably a scholar and an open-minded man.

In later years, when rigid-wing flight had come back to public favor out of the eclipse into which it had earlier gone, Count D'Esterno made arrangements with Jobert, another Frenchman, who had built several flapping-wing models of varying excellence, to build a glider for soaring flight. This was in the year 1883. Count D'Esterno was seventy-seven, and presently he died, before his soaring glider had passed beyond the stage of diagrams and discussions.

A few years after D'Esterno, the French Academy of Sciences was privileged to receive a communication which described what was certainly the most original conception of a mechanical bird that had ever sprouted in any human brain. This particular brain belonged to M. G. Trouvé.

In the Trouvé machine the flapping wings were to be connected to the ends of a copper tube bent in a circle. Anyone who has ever taken a steam gauge apart will remember that just such a device is used to move the pointer over the scale. As the pressure in the bent tube increases, the tube attempts more and more to straighten out. Trouvé proposed just such a use of this tube — and he provided a means whereby the tube

would be alternately straightened out and contracted. These changes in shape would be small, but the tube would feel so violently about them that the length of its motion could be magnified through linkages to cover a greater distance, and the wings could be made to beat a good strong vigorous stroke in consequence.

The alternate expansions and contractions of the bent tube were to be brought about by a revolving magazine, containing twelve cartridges. An ingenious starting mechanism provided that when the bird was released by the burning of a thread, the revolver mechanism was released also and the hammer would strike the first cartridge. The explosion gases would blow into the bent tube, which would straighten out violently. The wings would beat down sharply. The reaction would swing the next chamber of the revolver into line and exhaust the gases from the tube, which would contract. The wings would reverse their direction. The hammer would draw back, catch for an instant, and then fire the next cartridge. The entire cycle would be repeated. This action would continue until all of the twelve cartridges in the revolver had been fired.

Now all of this sounds like the description of a highly visionary and impractical project. But, as a matter of fact, a small model built by Trouvé upon this principle actually covered a distance of over two hundred feet. Trouvé's mechanical bird was only one of myriad devices which sound absurd on paper and yet which really do operate when put to an actual test.

For a full-size machine Trouvé had the rare imagination to propose carrying compressed hydrogen as a fuel. With this he would mix three parts of air, so that the ratio of hydro-

gen to the oxygen of the air would be about two to one. An electric spark inside the bent tube would then ignite the gases. Here Trouvé was making use of a principle which may possibly, at some day in the future, prove vital to the complete success of aviation — which is still troubled by the problem of weight of fuel.

In 1886 Trouvé, after five years of research on the propeller principle, beginning with the study of marine screws on launches, came to the conclusion that the flapping-wing mechanism which he had originally proposed was inferior to the rigid wing that was propeller-driven. He made a number of investigations whose correctness is still acknowledged to-day.

In England, in 1879, the first Honorable Secretary for the Aeronautical Society of Great Britain took out a patent on a sinuous machine to weave itself through the air on the same principle, as the inventor freely confessed, by which that unlovely fish, the skate, navigates the water. The skate has no fins; but on either side of its spine its body trails off into thin, waving leaves. While these leaves flap up and down in the water, a peristaltic wave travels along them from front to rear. In the skate this produces an almost disgusting gracefulness. The Honorable Secretary, Mr. F. W. Brearey, proposed that this same idea be applied to an aerial fish of his own design. He built models on this unique principle — with a central spine and vibrating wings at the front which carried waves backward through the flexible fabric to which they were attached. A small model, about five feet by eight feet, flew, when released from his hand, for a distance of sixty feet. Thus encouraged, he made plans for a steam-powered machine which would carry six hundred to seven

hundred square feet of undulating canvas. He thought so well of his design that he patented it not only in England, but in the United States. Here was a cheerful and optimistic soul who thought that the power necessary for flight was greatly overestimated by his fellow workers. But all of his optimism was insufficient even for the construction, much less the operation, of the large-scale flying skate.

By now, interest in heavier-than-air flight was breaking out in every direction — and upon every principle. Even Thomas Alva Edison succumbed to the lure of the helicopter. In those days Mr. Edison had no great commercial factories in Orange, New Jersey. He was the "wizard of Menlo Park," who had produced the phonograph, the incandescent lamp, and the forerunner of the modern dynamo.

There lived in Mr. Edison's vicinity a man then equally well known, whose fame has since oddly vanished. He was James Gordon Bennett, publisher of the then great newspaper, the *New York Herald*. It was he who, in 1880, urged upon Thomas Alva Edison the necessity of making some studies on heavier-than-air machinery. Mr. Edison began cautiously with an attempt to determine the efficiency of the aerial screw of Leonardo da Vinci as a lifting mechanism. He used an electric motor of small horsepower, connected to a vertical shaft, to drive a propeller. To the shaft carrying the propeller there was attached a weight, and this weight rested upon a platform scale. Edison had set himself the problem of determining how much different types of propellers would lighten the apparent weight on the platform scale when revolved at different speeds. Apparently his best results, obtained by a large, awkward, sprawling fan, only lightened the total weight of his apparatus of 160 pounds by some four

or five pounds. Yet he did come out to a reasonably exact conclusion about aviation. "The thing never will be practicable until an engine of fifty horsepower can be devised to weigh about forty pounds."

The truth lay between the Messrs. Brearey and Edison. Brearey wanted too little; Edison wanted too much. And yet it will be obvious to everyone that the experimenters in this chapter, lacking, as they did, any legitimate issue so far as aircraft went, were still in their own odd ways coming closer and closer to the truth out of which heavier-than-air flight was eventually to be achieved.

XV

GLIDERS MAKE THE GRADE

If men had continued the attempt to solve the problems of heavier-than-air flight — stability, manœuvring, structural strength, motive power — all in one swoop, this story of aviation would be much longer and men would sweep the skies to-day with much less abandon than they do. From the days of Henson and Stringfellow experimenters had first concerned themselves with motive power, not realizing that Sir George Cayley, years before, had in the glider a mechanism with which to navigate the ocean that came to every man's door. But the question of motive power stubbornly refused to be solved. Steam engines were too heavy and there seemed nowhere else to turn.

Thus blocked off from any satisfactory means of powering their planes, men began to look to the planes themselves. One of the greatest experimenters of what was shortly to become a new era likened a glider to a bicycle that had no pedals or cranks, but on which one could very handily learn to balance by going down an incline. The year 1890 dawned inauspiciously. Scientists had all but abandoned the idea of finding any means to apply power to heavier-than-air flight, and by abandoning it they opened up a new age in aviation.

The first of the new experimenters was Otto Lilienthal, born in Anklam, Pomerania, in 1848. Like most experimenters who have written their names large in the history of aviation,

he seems to have been born with the desire to fly. Aviation never had a more thoroughgoing and enthusiastic student.

His first experiments he undertook at the ripe age of thirteen. With his younger brother Gustav he made wings out of wooden frames covered with linen. These Otto would attach to his arms and with them run madly down a hill, flapping them like a rooster pursuing a bug. The mob spirit sets in early; the lust to ridicule people who do things that common folk do not think of flourishes in every climate and at every age. The young boys of the neighborhood thought Otto a freak and his flapping wings and desire to fly both presumptuous and absurd. They laughed at him. Thereafter these experiments were confined to moonlight nights.

Storks were common birds in Pomerania, and Otto and Gustav tried to study their soaring flight. Otto wrote: "For thousands of years we human beings have racked our brains to unravel the mysteries of flight and we feel happy when we drink mere drops from the Font of Knowledge, and here the storks seem to run riot in the art of flying, as if nothing in the world were easier." By 1867, when Otto was nineteen, the two boys had gone at their problem in earnest. They knew of Besnier, the French locksmith, who had jumped from his garret. And so the first mature gliding experiments of the Lilienthal brothers were made with wings mounted on Otto's back, and moved by cords connecting them with his legs.

But the Franco-Prussian War interrupted the studies of these two young German lads. Both boys saw service, Otto as a volunteer in the Fusilier Regiment of the Guards, which took part in the siege of Paris. Not until 1871 were they able to resume their abiding peace-time interest, and by this time the interest of the more prosaic brother was waning. The

idea that possessed Otto almost to the point of mania began to seem rather silly to Gustav, and presently he left Otto to continue by himself.

Then Otto went at the science of aviation from the ground up — both literally and figuratively. He felt convinced, this sober German boy of twenty-three, that his predecessors had jumped at too many conclusions; had accepted too many facts at second hand; had taken, without verification, the word of too many other people. Otto would do none of this. He would rely only upon his own observations, his own experiments. He would build up his own science of aviation from the very beginning. With remorseless thoroughness and magnificent logic, he began a long series of experiments the object of which was to measure the amount of resistance to the air the bird's wing has to overcome when in motion.

Then, by 1891, Otto Lilienthal was ready. He had covered his groundwork in systematic style. He was convinced of what he ought to do and how he ought to do it. With his observations, his principles, his drawings, close at hand, he built his first glider. The machines of many other men had been constructed largely out of hope and enthusiasms. They flew, some of them, but sometimes design and performance were little better than coincidence. Yet there was hope in Lilienthal's machine, great hope. There were high enthusiasms, too, for when he built this glider in 1891 out of peeled willow rods, with one hundred square feet of strong cotton fabric stretched over them and covered with wax, he knew that he could fly with it. And fly he did.

It is typical of the Teutonic thoroughness with which Lilienthal tackled his problem that in 1889, two years before his first take-off, he published a book on gliding. He understood

the subject thoroughly before he ventured to try it himself. When he finally launched himself into the air from a springboard and glided his first few feet, it was after twenty years of preparation.

Gradually Lilienthal got experience; got the feel of his glider in much the way one learns to ride a bicycle, balancing skillfully but without knowing how. He supported himself from the framework by the forearms, with his body hanging free below the plane of the wings.

" Almost every Sunday," he said, speaking of the early days of 1891, " and sometimes on week days, I went out to practise on the hill between Gross Kreutz and Werder. A mechanic, Herr Hugo Eulitz, the maker of my apparatus, went with me, and each practised alternately while the other rested. Thus we obtained dexterity in gliding down on the air and in landing at the foot of the hill without mishap.

" Herr Kassner, of the Meteorological Institute, was so kind as to photograph me in the air, and has thus enabled me to exhibit to the members of the Society [it was the Deutscher Verein zur Förderung der Luftschiffahrt] how I sailed right over the head of the miller of Derwitz (in whose barn I stored my apparatus) and of his esteemed poodle dog."

Herr Lilienthal (for he is not young Otto any more) soon outgrew his springboard jumps. Practice on the hills close to Berlin was his next step. In the summer of 1892 he went further. He built a roofed hut at the top of a hill to supply even greater elevation. Seldom, however, was the wind favorable at Maihöhe, so he abandoned this a while later for more suitable grounds in the Rhinow Mountains near Rathenow. Then, in 1894, a contractor began cutting through a canal near Lilienthal's Berlin home. What was useless waste

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SOARING LILIENTHAL

The First Great Master of the Art of Gliding (*Page 142*)

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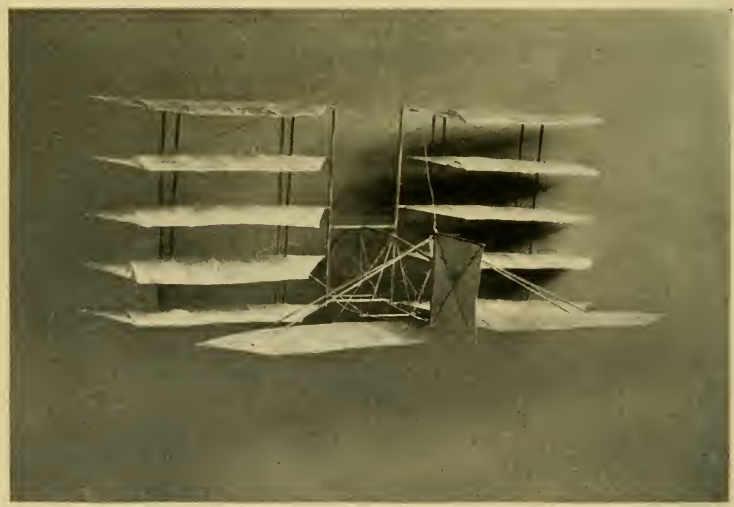
COMPRESSED AIR ORNITHOPTER

The Invention of Laurence Hargrave (*Page 129*)



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THE GLIDER OF OCTAVE CHANUTE

A Model of His Famous Quinqueplane (*Page 153*)

material to the contractor was precious stuff for Lilienthal. He quickly made arrangements to have an artificial hill from which to fly built up out of the earth dug from the path of the canal. This, at Gross Lichterfelde, furnished him with an ideal practice ground, for the natural contour of the surrounding country was flat, and into the bargain there was not as much as a house or a tree to make the wind fickle or gusty and he could use it no matter what its direction. Lilienthal's homemade hill was conical in shape and fifty feet high, and with true economy he made it serve the double utility of take-off point and hangar. At the bottom he provided a cave large enough to store his glider.

From this and other hills, no longer met by the jeers that greeted him as a boy, but observed with amused condescension by the townsfolk of Berlin out for a Sunday airing, Herr Lilienthal between the years of 1891 and 1896 made something over two thousand gliding flights. He grew more and more expert. Under his guidance the glider became a mechanism that could be controlled; that would no longer, as with Le Bris and the coachman of Sir George Cayley, spill its occupants amid splinters upon the ground. Lilienthal learned — and he was the first man to learn it — how to keep a glider stable by moving his legs about beneath the machine. With increasing skill his flights increased in length to an average of three hundred horizontal feet from the take-off point on his hill, and he made this distance at a gliding angle often as flat as one in ten. He learned not only to keep his stability under remarkable control, but to manœuvre in curves and turn about in the air with surprising quickness by throwing his weight to the side toward which he wished to turn.

By 1895, Lilienthal had given up the monoplane gliders

with which he had so far worked exclusively and had built biplanes with which, he felt, he obtained better results. "Six or seven metres velocity of wind," he said, "suffice to enable the sailing surface of eighteen square metres to carry me almost horizontally against the wind from the top of my hill without any starting jump. If the wind is stronger, I allow myself to be simply lifted from the point of the hill and to sail slowly toward the wind.

"The direction of the flight has, with strong winds, a strong upward tendency. I often reach positions in the air which are much higher than my starting point. At the climax of such a line of flight I sometimes come to a standstill for some time, so that I am enabled, while floating, to speak with the gentlemen who wish to photograph me, regarding the best position for the photographing."

By 1896, Lilienthal could lay easy claim to being the most practised aviator in the history of the world. The aeronauts who flourished in an earlier day and whose wane had just begun had spent more hours in the air, but not at the constant expense of skill and dexterity which kept Lilienthal supported 50 to 75 feet in the air — 170 pounds of aviator and 53 pounds of glider itself, sustained by 172 square feet of wing surface.

Lilienthal had approached aviation from the right vantage point. Much though he must have yearned to work with a powered machine, he kept it out of his thoughts until he felt certain that he had mastered the difficult problem of stability — which men, in their earlier enthusiasms, had recognized but somewhat neglected. In 1896, after five years of powerless gliding, Lilienthal felt confident that the day had come. He had built a two and one-half horsepower motor which

weighed ninety pounds and was a large-scale adaptation of the compressed-air machine which Hargrave had used to drive his delicate models in New South Wales. There was this difference: Lilienthal relied upon a tank of compressed carbon dioxide, that same gas which had been used a short time before in America to create the world's newest drink, the ice cream soda. He believed that he could store enough carbon dioxide to drive him through the air for four minutes, during which, as was his modest hope, he could travel several miles. A hand-operated valve would act as his throttle, and instead of using a propeller he arranged his power machine so that the tips of his hitherto rigid wings would flap.

Minor accidents delayed the start, and the day of the first test for the power machine was slow in coming. Finally the last difficulty was cleared away. The power machine was ready for ascent. But beforehand Lilienthal would make a gliding flight.

Now the career of this methodical German had been extraordinarily free from mishap. He felt that he knew almost everything there was to know about gliding, and he governed himself accordingly. But this day of the trial of the new power machine was notable for another reason also. Lilienthal had applied a horizontal rudder to his biplane glider, and, being unable to use either his arms or legs for the purpose, had fastened the rope by a band about his forehead. When he moved his head forward, he would thus lift the rudder and soar upward. When he moved his head back, the rudder would return to its normal position. The wind was moderate, but not too steady. The glider took off and swiftly reached a good altitude. Then a sudden lull in the wind brought it to a standstill in the air.

Five years of controlling the stability and direction of his machines only by the distribution of his weight had given Lilienthal a set of flying habits not to be broken casually in one afternoon. With his plane stalled in mid-air, he sought cautiously to incline it forward enough to give it a new velocity. But the unfamiliar control system confused him. The plane, which a moment before had been lying placidly in the air, shot down suddenly, straight for the earth, its wings knifing through the air like a falling rocket. It struck. The fall had been from a height of fifty feet, and Lilienthal could not speak to the watchers who lifted him from the wreck. His spine was broken, and this painstaking German, who between the ages of thirteen and forty-eight had given his every thought to the advancement of aviation, gave his life also the next day. The powered plane which carbon-dioxide gas was to have driven through the air for the final realization of Lilienthal's dream gathered dust and disappeared.

Lilienthal died with ten or fifteen years more of work still in him. Yet even at forty-eight, death did not come to him before he had established half a dozen principles of the highest importance in aviation. Safety, men learned through him, lay in the use of small gliders, not large, since large machines require more skill to handle and are less easy to manœuvre. Safety did not increase with wing area, as had been thought before.

The problem of stability should be considered first. Let men experiment as much as they please with powerful motors of light weight, but let these not be applied to planes until the more important question of sustaining one's self in the air is completely solved.

Once and for all, Lilienthal exploded the shell of mystery

that had surrounded gliding flight since the days of Besnier. It was, he showed, merely sailing on the wind, and no mysterious question of "negative gravity" entered into it to the smallest degree. "To conceive a flying machine is nothing. To construct one is little. To fly is everything." So said the man who as a boy of thirteen had fastened wings to his shoulders and gone flapping roosterlike downhill.

He said also, "Man must serve an apprenticeship to the birds." No one in aviation served a finer or more useful one than Otto Lilienthal.

XVI

LILIENTHAL'S PUPILS

Otto Lilienthal had two great pupils. Both had known his work; one had watched his flights, and had the benefit of his advice and experience. One man brought the ideas of Lilienthal to England; the other, although born in Paris, carried them to America. One of them was killed at the age of thirty-four; the other had scarcely seen a glider until he reached the age of sixty. The youth who lived in England was Percy Sinclair Pilcher. The veteran who worked in the United States was Octave Chanute.

Pilcher had a precocious start in life. Before he was nineteen years old he had been an enlisted man in the British Navy. Pilcher began to build gliders in 1895 at the age of twenty-nine. The first one was a monoplane, called by that popular title, the Bat. But after it was built it occurred to him that science and discretion might both be served if he visited the great Otto Lilienthal before he made his trials. So he journeyed to Berlin and met the great German master one year before his death.

With his new experience Pilcher returned to Cardross on the Clyde. The wing tips of the Bat were raised four feet above the body, thus producing a dihedral angle that was most pronounced. By the theory of the 1890's, this should have helped stability. In practice, the Bat turned out to be an erratic flier, even though it and its navigator weighed much

less than did Lilienthal's glider and Lilienthal. Pilcher weighed only one hundred and forty-five pounds, just an even hundred pounds more than his glider.

Pilcher made his first jump from a natural hill on the banks of the Clyde. The dihedral angle was too great and the lack of any horizontal tail showed up clearly as another defect. Nevertheless the Bat did fly after a fashion. Pilcher immediately reconstructed it, added the needed horizontal tail, and reduced the dihedral angle so that the wing tips were only six inches above the level of the body. Immediately results improved. Pilcher rose twelve feet into the air and stayed there for twenty seconds.

With the second attempt he returned to a method of launching that Lilienthal never used — one that men seem to have viewed with suspicion after the days when Le Bris soared upward with his cart driver dangling below him. Pilcher eliminated the cart and harnessed his glider directly to a span of horses.

Unlike Le Bris, however, he carried up no inadvertent and unwilling baggage. The horses went off at a gallop. The glider, dragged behind them, rose swiftly. Pilcher cast off his rope and enjoyed a glide that lasted a minute and lifted him twenty feet. He practised this mode of ascent diligently and became expert at it. But his Bat was apparently none too stable a gliding machine. It would balk frequently, spill Pilcher onto the ground, and then fall on him. Both he and the Bat required frequent patching.

After a time he gave up the Bat and built the Beetle. This was a larger glider with rectangular wings clipped off at the corners. Pilcher provided it with a space in the centre in which the pilot suspended himself by the forearms as before.

But this glider weighed 80 pounds, for Pilcher had constructed it with an eye for possible use with an engine later. Accordingly the total combined load was 225 pounds, which had to be supported by a wing area of 170 square feet. This load was too much: the centre of gravity was too low into the bargain; the glider was hard to handle and never proved a satisfactory flier.

So in 1896 Pilcher built his third glider and called this one the Gull. It weighed only 55 pounds, but its wing area was 300 square feet. The Gull had overcorrected the deficiencies of the Beetle. It was too large and unwieldy for use except in the calmest of weather. The Hawk, therefore, followed swiftly — fourth in Pilcher's ornithological series. Yet in spite of its nobler name the Hawk bore a curious resemblance to the earlier Beetle. Once again the ribs were bamboo; once again the wings were stiffened by two masts and stays; once again space was provided in the centre for Pilcher to hang on by the forearms, his head and shoulders and part of his chest above the wings. Like Lilienthal, he achieved stability by altering the position of his body.

Pilcher made twelve glides with the Hawk during the summer of 1896. It was by all odds his most successful model. Like Lilienthal, Pilcher aspired to apply power to his machine, although, unlike him, he preferred the propeller to the flapping-wing mechanism.

In 1898, Pilcher set to work on an engine of four horsepower. It was to be fitted into a new triplane, which he later built and in which he expected to incorporate Laurence Hargrave's ideas on soaring box kites. The engine was to be fitted in in front of the operator and, by means of an overhead shaft, was to operate a pusher-propeller behind the wings.

The new machine, like Lilienthal's, was never flown. Pilcher had promised to give a demonstration flight in the new machine on September 30, 1899, at Stamford Hall, Market Harborough. The day broke with a misty rain and Pilcher decided that it would be safer to use his well-tried Hawk than his untried triplane. But true to his promise, he hooked his two horses to the Hawk and rose easily behind them as they galloped across a level field. The towline snapped when the Hawk was well cleared of the ground, but before it had attained the altitude that Pilcher desired.

Though heavy with the rain, the Hawk descended easily, and Pilcher decided to try again. Once more the horses were harnessed to the towrope and the towrope fastened to the Hawk. Once again the horses' hoofs splashed over the soggy field. Once again the Hawk rose easily into the air.

At thirty feet altitude the slender guy wire bracing the triangular tail snapped, twanged and whipped back. The tail of the Hawk collapsed. Stability gone, it fell suddenly and turned over as it struck. Pilcher was unconscious when they lifted him from the wreckage. The hope for his recovery lasted for two days, but, without ever regaining consciousness, he died on October 2, 1899, aged thirty-four.

Octave Chanute, in the same years that Pilcher flourished, was spreading the gospel of Lilienthal in America. He was born in Paris in 1832. At the age of six he was brought to America. After being educated in New York City, he began professional life as a civil engineer. It was in October 1891 that the world discovered the deep interest which Chanute took in aerial navigation, through the publication of a series of articles called "Progress in Flying Machines." And five

years later, in 1896, when he was sixty-four years of age, he began his first gliding experiments.

Chanute made his own first gliding flights in the year before Lilienthal was killed. But, to his older and more conservative way of thinking, the Lilienthal type of machine was more hazardous than it should be. Particularly did Chanute dislike the idea of maintaining stability exclusively by shifts in the operator's position. Being an old man, he felt that the operator should remain seated in one position in the machine and should interfere with its movements only to steer. There should be a mechanism to adjust the wings automatically as the sustaining pressure under them varied. He knew quite well that he could learn little about this from models — accordingly he took to the air himself.

A man in his sixties has not the resiliency of youth, and Chanute was able to make only short glides. So he contented himself with being primarily a groundsman and entrusted to his two assistants, Herring and Avery, the task of making the actual flights. But it was Chanute whose ready, active brain schemed and designed and worked for the improvement of gliding flight.

Among the sand hills on the shore of Lake Michigan, thirty miles east of Chicago, he began his work. The modest start in 1895 brought swift results. By 1897 he was working with a staff of from four to six men and had turned out and tested five full-sized gliders. From his researches two types evolved. One was a biplane roughly similar to the machine in which Lilienthal had plunged to his death. The other had five tiers of wings and looked like an enormous Venetian blind opened out.

But further experiment definitely proved the advantages of

the biplane over the multiple-plane glider, which, as gradually became evident, was unnecessarily cumbersome. Chanute's biplane made almost 800 glides, the longest one, 360 feet, excelling the records of both Lilienthal and Pilcher. Speed usually averaged between 22 and 30 miles per hour, but once reached the startling figure of 52. Chanute had no qualms about experimenting in rather stiff winds. Whereas Lilienthal had begun by gliding when wind velocity was between 11 and 13 miles and had definitely stated that a speed as high as 23 miles made gliding downright dangerous, Chanute often worked in breezes much stiffer than this, and once flew his biplane against a wind which was traveling in from Lake Michigan at 31 miles per hour. Yet in all this time no accident ever befell him or any of his co-workers. The biplane design proved so stable that Chanute occasionally let amateurs try a whirl with it under proper guidance, and not even then did any accident mar his perfect record.

Almost alone among experimenters with heavier-than-air machines, Chanute was bothered by no ambitions to apply power to flight. His one desire was to learn everything he could about the problems of stability and how it might be controlled. When those problems were solved, he thought, there would be time enough to hoist one of these new, sputtering, internal-combustion engines aboard his delicate structures of pine and linen to see if the application of power could be made to cause free, spontaneous, man-carrying flight.

Before, during, and after the years that Lilienthal, Pilcher, and Chanute flourished in Germany, England, and America, a nearly forgotten American was busy with his studies in California — thousands of miles removed from anyone effectively interested in flight. He was Professor John J. Montgomery,

of Santa Clara College. Entirely unhonored, almost unknown, it was he who instituted gliding upon a really grand scale.

He built his first flying machine — it was of the flapping-wing type — in 1883. Naturally it was not a success. But in 1884–85 he built three gliders, and very effectively demonstrated the superiority of curved wing surfaces over flat ones. These three gliders were of different types: one had the wings of a sea gull; the second had plane surfaces; the third had the pivoted wings which were to appear later in the famous Antoinette type of powered airplane used by Latham in his cross-Channel attempts. Montgomery could change the wing angle of the plane while in the air, an ability which pilots found immensely valuable in manœuvring. They could glide in circles, fall steeply, or even rise a little by proper manipulations. The three points which the Professor's academic mind kept constantly before him were equilibrium, complete control, and long-continued flight.

Then, after experimenting in the steep San Juan Mountains, assisted by cowboys, Professor Montgomery devised the scheme which really put gliders to the test. In 1905 he found a parachute jumper, by name S. M. Maloney, who was daring enough to go up 3500 feet in a glider suspended from a hot-air balloon and to cut loose at that height. The glider was a tandem monoplane; each curved surface was twenty-four feet long and four feet wide. There was a vertical keel, and rudders for horizontal and vertical steering. The test was made in public on April 29 of that year; the results were successful and spectacular. Maloney swooped, soared, and circled down like a bird. The San Francisco earthquake, in 1906, cut short Professor Montgomery's experiments. He

was able to resume them only in 1911. And in October of that year his glider was caught in a sudden gust and Professor Montgomery was killed in the resulting crash. For all his boldness and success, the name of the first native American to build and operate successful gliders is almost wholly lost to fame.

XVII

THE LOST DISTINCTION

Lilienthal, Pilcher, and Chanute — each had partially solved the problem of stability and had devised a satisfactory and workable structural form for the airplane to take. They had been apprentices to the birds; by closing their eyes deliberately to the more spectacular idea of flight under power they had so improved the structural design of proposed flying machines that man could once again with some confidence undertake the problems that had baffled Henson and Stringfellow.

There comes now on the scene one of the most puzzling enigmas in the history of aviation. Most of the world believes, on the best evidence, that the first sustained man-carrying flight under power was achieved by the Wright brothers from Kill Devil Hill, at Kitty Hawk, North Carolina, in 1903. But what are we to say of the modest, unassuming, and industrious experimenter who continued for years to insist that he had flown under power, and was able to produce impressive witnesses to testify to his performance?

He was Clément Ader, a French electrician who had been prominent in developing a telephone much used in Europe. He began his first experiments with aviation in 1872. Like De Villeneuve, he belonged to the flapping-wing school of design. He built an artificial bird 26 feet across and weighing 53 pounds — the wings of which were closed by the operator's

legs and opened by elastic, auxiliary pectoral muscles. The kitelike effect of the wing surfaces would lift a man in a high wind, but Ader, like so many countless others before him, found that the operator lacked the strength to keep his wings going. The bird never left the ground. This was a sticker for Ader. During the next fourteen years he went back to his electricity and left aviation strictly alone.

Ader later told an interesting and plausible story of his beginnings in aviation. His first step, he said, was to obtain eagles and large bats from the Zoölogical Gardens and to observe their modes of flight in his laboratory. But this was not enough. He went to Algeria to hunt for large vultures, but could find none in the vicinity of Constantine. So he disguised himself appropriately and plunged into Arabia, accompanied by two guides. There, with large pieces of decayed meat, he enticed the necessary vultures into sufficiently close range. He took ample data from his observations, so his story ran, and returned to France fully convinced that a beating-wing mechanism was not necessary; that his vultures, some of them ten feet broad from tip to tip of wing, flapped only two or three times as they left the ground and soared thereafter.

Then, in 1886, after studying the vultures, he built another batlike machine which he called the Éole. This time, however, the wings were stationary, and Ader used steam power to drive one four-bladed propeller. The tests were held in the closest privacy four years after the start of construction, and the results were mysterious and obscure.

In 1892, Ader built the ship which created and still leaves behind a puzzling obscurity. He called it the Avion, now the generic French name for all heavier-than-air machines.

It was powered by two steam engines developing twenty horsepower each; it was driven by two four-bladed propellers and rested on three small wheels. Even the folding-wing machines of this present day are nothing new under the sun, for the Avion, built by Ader in 1892, was equipped with wings that really folded, like a bat's.

The trial of the first Avion was held at Satory, a military post, and French military authorities were present. We have little accurate description of what happened on that test, although there is every reason to imagine that it was ended with some measure of success — if only because, despite the official delays and inevitable red tape connected with an army of any nationality, the French War Ministry did grant Ader funds for further research.

With these funds Ader immediately began the construction of his second Avion. Its first trial was held on October 12, 1897, in the presence of General Mensier, who admitted that the machine made several "hops" from the ground.

Two days later, the second trial was held. General Mensier was again present, this time with General Grillon, Lieutenant Binet, and the Messrs. Sarrau and Leute, both professors of engineering at the École Polytechnique. The weather was fine but gusty. Toward sunset the air became calmer, and at 5.15, with a following wind, Ader started his machine down the path. The rear wheel, used for steering, rose from the ground, and after a moment the machine swerved and up-ended. The question now to be answered was: Did the machine fly, or was it raised off its path by a gust of wind? The expert witnesses straddled the question by saying that the Avion was apparently "capable of flight," and the Generals Mensier and Grillon found themselves quite at odds as

to what happened. They relieved their feelings by sarcastic references to each other in their reports, but they were not notably helpful in clearing up a difficult question in aeronautical history.

Ader remained forever after quietly convinced that it did fly. This was his quiet, sensible, and restrained account, published in 1910, thirteen years after the last baffling exhibition of Satory: —

After some turns of the propellers, and after traveling a few metres, we started off at a lively pace; the pressure gauge registered about seven atmospheres; almost immediately the vibrations of the rear wheel ceased; a little later we only experienced those of the front wheels at intervals. Unhappily the wind became suddenly strong. . . . It [the Avion] found itself in a very critical position; the wind blew strongly and across the direction of the white line which it ought to follow; the machine then, although still going forward, drifted quickly out of the area; we immediately put over the rudder to the left as far as it would go; at the same time increasing the steam pressure still more, in order to try to regain the course. The Avion obeyed, recovered a little and remained for some seconds headed toward its intended course, but it could not struggle against the wind; instead of going back, on the contrary it drifted farther and farther away. And ill luck had it that the drift took the direction toward part of the School of Musketry which was guarded by posts and barriers. Frightened at the prospect of breaking ourselves against these obstacles, surprised at seeing the earth getting farther away from under the Avion, and very much impressed by seeing it run sidewise at a sickening speed, instinctively we stopped everything. What passed through our thoughts at this moment, which threatened a tragic turn, would be difficult to set down. All at once came a great shock, splintering, a heavy concussion: we had landed.

Had they? If they had, they had also made the first free man-carrying flight through the air under power that any man had ever achieved. Aeronautical history still presents this unsolved enigma.

Sir Hiram Maxim conceived aviation on a scale that no man had dared to think of before. He could afford to. He had invented a writing telegraph, several systems of electric lighting, and the machine gun which still bears his name. They had made him wealthy, and he had left his native United States to live and carry on further experiments at Bexley, in Kent, England.

Sir Hiram was a vivid personality. He had the habit of saying what he thought, and saying it forcefully. He seems to have had two strong aversions: the French nation, and the idea of lighter-than-air flight. "The French," said he, "have agreed on the term 'aviation' in case they ever succeed in flying"—a remark that was perhaps a trifle ungenerous considering that up to that time the French had done twenty times as much as any other nation to promote flight.

And Sir Hiram paid his respects to lighter-than-air machines with equal force: "It is quite as impossible to propel a balloon with any velocity through air as it is for a jellyfish to make high speed."

He had some salutary and cleansing things to say about gentlemen who insisted that the flight of birds provided the only principle upon which heavier-than-air machines could operate. If an airplane must be built like a bird, said he, then why should we not build locomotives on the principle of the horse? He went on to calculate that if this principle had been followed locomotives would weigh as much as

elephants and could make a speed of five miles per hour.

Sir Hiram began his experiments with models of screw-propelled planes. No one was ever before so active in measuring the different forces which acted upon them. Even his models he kept tethered at the end of the arm of an elaborate machine which he built to whirl them about in a 200-foot circle at speeds up to 90 miles per hour. His machine was equipped with gauges whereby he could measure the lift of the wing and any other quantities he desired. He experimented with many types of wing surface and many kinds of aerial screws. "The screw which gave the worst results was made exactly like those employed in the experiments of the French government," he said, with another bow across the English Channel.

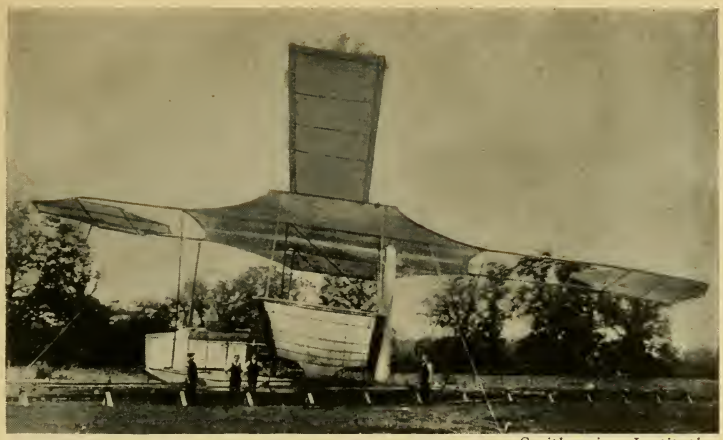
In 1893, Sir Hiram began experiments with a plane consisting of a main wing that looked like a vast canopy sheltering the propellers, engine, and pilot underneath. This wing was 110 feet long and 4 feet wide, made of a frame of steel tubes covered with silk. He called his wing a "plane" and used one great central plane with various other smaller hinged ones for the correction of equilibrium changes. The total wing surface was 5550 square feet — twenty-five or thirty times the average figure for the modest gliders of Lilienthal, Pilcher, and Chanute. It was the longest machine to be built until Glenn Curtiss's flying boat America was built for a trans-atlantic attempt in 1914. From the front end of the plane to the rear tip of the steering gear was a stretch of 145 feet. In this machine Sir Hiram lodged a 300-horsepower steam engine.

Sir Hiram was anxious to collect all the data possible from the operation of his giant machine before attempting free

flight. He made a positive fetish of his desire for figures, and, having spent thousands of dollars in designing and building a plane which he was sure would fly, he then devoted all his attention to finding ways of weighting it down so that by no possible means could it fly when he tested it. Through the private park which made up his estate he built half a mile of railroad track, with a nine-foot gauge, for the preliminary trials. At the bottom of his flying machine he placed iron wheels, axles, and connections weighing a total of one and a half tons. A light running gear for use when he really intended to fly Sir Hiram held in the background.

He arranged his connecting mechanism so that his plane could rise to a height of six inches before the weight of the heavy iron trucks restrained it from further ambitions. Yet, in spite of this running gear, his lumbering machine one day started down the runway into the teeth of a gentle ten-mile wind. There came a sudden gust which lifted the 5000-pound machine with its 3000-pound wheels bodily off the track, dumped it on to soft ground at the side, and blew it over into the bargain — just to show what a ten-mile-an-hour zephyr thought of a four-ton bird when it kicked up its heels. The combination of engine power and gust had produced, with a wing surface of 3160 square feet (some of the smaller surfaces had not been broken out), a speed of 27 miles per hour and a lifting force of 6000 pounds.

But Maxim was determined that his flying machine must not, at any cost, be permitted to fly. He abandoned the wheels that had played him false and added a safety track to his right of way. These were squared pine logs, three inches by nine inches, placed two feet above the steel track, with a thirty-foot gauge. To his flying machine Sir Hiram added



Smithsonian Institution

SIR HIRAM MAXIM'S ENORMITY

Had He Let It, It Might Have Flown (*Page 163*)

Brown Bros.

EARLY ENTHUSIASTS

The Gentleman in the White Duster is Colonel Cody, an Early American Aviator. In the Centre is the Famous Sir Hiram Maxim, who All But Flew in the Nineties (*Page 162*)

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SAMUEL PIERPONT LANGLEY

Who Died of Disappointment
(*Page 169*)

Smithsonian Institution

AN EARLY AERODROME

One of the First of Professor Langley's Model Fliers
(*Page 170*)

four extra wheels, fitted on outriggers, and designed not to touch the ground at all, but to catch the undersides of the pine logs if the flying machine dared to fly higher than two feet from the surface of the earth.

With this new precaution, he was once again ready to make one of his curious flights. His engine he had tuned up to the last degree of efficiency. He made one run on his newly safeguarded tracks at a steam pressure of 150 pounds per square inch. For all the manifestations of flight which his machine showed, Sir Hiram might have been piloting the Toonerville Trolley. On the next run, he took a hitch in his courage and increased his steam pressure to 230 pounds. This time the flying machine complimented him by bumping periodically between the lower and the upper tracks. For the third trial, accordingly, he began his steam pressure at 200 pounds and went to 310. But this time the machine was hitched to dynamometers at the rear, and was not free to run. The thrust of the propellers, so these dynamometers showed, was 2164 pounds.

The boiler which was producing steam for his marvel of engineering efficiency was a water-tube affair of the Thornycroft type. It had 48,000 brazed joints and was heated by no less than 45,000 gas jets. In a later design, he reduced this figure to 6000 gas jets, still certainly enough. The gas was naphtha. The inventor had found it necessary to design a variable stroke pump which would deliver greater or less quantities of fuel to the burners, depending upon the condition of the steam supply.

Sir Hiram had an ingenious solution for the problem that is always created by the emission of steam from the cylinder port. The locomotive prodigally casts it out. If Sir Hiram had

been contented to do the same he would have been forced to carry between twenty and twenty-five pounds of water for every horsepower developed, multiplied by every hour he remained in the air. This was obviously impossible if flights of satisfactory duration were to be realized. Sir Hiram met the problem in his usually ingenious way. He made the framework of his plane serve a double purpose. It was first a framework. It was second a condenser — since its hollow tubes were of metal, and exhaust steam, circulating through them, would be cooled to liquid temperature by the rush of the wind.

There came the magnificent day when Sir Hiram was ready to make a full-pressure run on his track. Everything had been prepared with the utmost care. Sir Hiram climbed into his seat and turned on the steam so fast that his crew were nearly knocked off the plane. The flying machine began thundering down the loose pine track, every one of its 6000 burners going, water flashing into steam, pistons and valves turning over madly, propellers whining in the air. Notwithstanding all this activity, the boiler pressure went above what the engine could use. At 320 pounds the safety valve blew; there was a pop and then a sibilant hiss, and a plume of steam marked the riotous course of the flying machine. By the time it had traveled 600 feet, all four of the special outrigger wheels were straining upward against the thirty-foot-gauge pine logs. Sir Hiram, seated proudly in the pilot seat, jaws clamped together, pulled the throttle as far back as it would go. But he was the victim of his own scientific cautiousness. Nothing in the world was keeping his vast flying machine on the ground except his own incredible caution. It wanted to fly; it wanted to fly more desperately than any mechanical

thing had ever wanted to since the wooden pigeon of Archytas first made its way into history more than twenty centuries before.

But, regardless, the pine-lumber track held firm. For another hundred yards the machine went zooming along. Then, at 900 feet, one rear axletree could stand the strain no longer. It was made of two-inch steel tubing, but the longing of this flying machine for its element was too much for it. The axle buckled up. Instantly it set the rear end of the machine free from the galling yoke of that beastly thirty-foot restraining track. The rear end soared upward and the pencils on the recording dynagraphs swept over to the far end of the cylinders. Here was altitude on a scale Sir Hiram had never dreamed of.

One hundred feet farther, the left forward wheel got away. The whole left-hand side of the machine soared crazily into the air, the one remaining outrigger wheel clinging like grim death to the under side of the track. Then a moment later it, too, got the best of its restraint, and ripped the track up altogether.

Sir Hiram now faced two difficult alternatives. He could hold his throttle wide open and keep on going. If he did so, he would certainly in a moment achieve free, man-carrying, power-driven flight. He would also, with almost no question, be killed as soon as his thundering, loose-jointed flying machine, minus any proper landing gear, attempted to come down. Or he might shut off his steam, hope that the plane would coast to a stop before any thick pine slivers of track, now weaving their way into the machine, pierced him through, and call it a day. He shut off the steam.

Hopelessly entangled with the track, the plane came to a

stop in another hundred feet, the remains of his landing gear skidding through the soft turf.

And therewith he gave up flying. He was no longer a young man; the fact that his flying machine seemed to want to fly was a trifle disconcerting to him. This was too bad. If it had not been for that soft pine track, the real cause of all his troubles, there seems no reason to doubt that Sir Hiram Maxim would to-day go down in history as the first man to achieve something approaching successful mechanical flight. He said, with complete justification: " Propulsion and lifting are solved problems; the rest is a mere matter of time."

Curiously, for a man of scientific vision, Sir Hiram dismissed the peace-time possibilities of the airplane with a wave of his hand. To him it was an engine of warfare. He insisted that it could not carry passengers. It could not move any quantities of freight. But he did lick his chops over the use to which the airplane might be put for military reconnaissance or bombing.

XVIII

AERODROMES

It was John Stringfellow who, in one way, brought the idea of power-driven flight to America. Before the year 1890 the contribution of the United States to aviation had been lamentably small. The carpenter Wilcox, the bold John Wise, and the unsung Professor Montgomery were the only three Americans of any consequence who had broken sky trails in this country.

But the model engine of John Stringfellow, which, in 1868, had won him the prize of £100 for the lightest engine for the power developed that had ever been designed, was presented in the year 1889 to the Smithsonian Institution in Washington, D. C.

Since 1887, Samuel Pierpont Langley had been secretary of the Institution. He was born at Roxbury, Massachusetts, August 22, 1834; in 1889, therefore, he was fifty-five years old, and, like Octave Chanute, a comparatively old man when he began the active study of aeronautics.

The delicate design of which John Stringfellow had been so proud had become with the passing of years nothing more than a historical curio — something to be kept under a glass case and looked at reverently. Langley, whom the idea of flight had obsessed for years, gave it many scrutinizing glances and made many computations of the power it might develop. He came to the conclusion that it could never develop more

than one tenth of the power that had been claimed for it, and that if he wished to develop a power plant strong enough yet light enough for use in a heavier-than-air machine he must make his own design. Internal-combustion engines were still unsatisfactory; steam with its heavy auxiliaries of burners, boiler, fuel, water, and condensers was still the best motive power available.

Before this, Langley had made more than thirty model planes driven by the elastic-band motor which Alphonse Pénaud had designed. They had flown steadily and well, and Langley, unlike Lilienthal, Pilcher, and Chanute, decided that he knew enough about the problems of stability to undertake to install power in a plane without the necessity of first learning to glide.

Langley was many men in one; he brought to aviation a magnificent equipment for success. He was a scientist of the front rank. He had the skill of a trained investigator. He had resourcefulness and enthusiasm and a long life spent in mastering difficult problems. He had, in fact, almost everything but luck.

By 1891, Langley had completed a long series of experiments to determine how inclined surfaces acted when propelled at high speed through air. He made a very positive statement of his ambitions and purpose. "Everything here has been done with a view to putting a trial aerodrome successfully in flight within a few years, and thus giving an early demonstration of the only kind which is conclusive in the eyes of the scientific men, as well as of the general public — a demonstration that mechanical flight is possible, by actually flying." Langley it was who definitely stated for the first time that the faster a surface is moved through the air,

the less energy is required to keep it up, which might be stated more loosely by saying that the air becomes harder and harder as you strike it with more and more force.

That word "aerodrome" is Langley's own. It means, literally, air runner, and Langley used it invariably, though it was popular with no one else.

In 1891, he began the construction of his first model-size power-driven aerodrome. He was anxious to include some sort of automatic steering device so that a long and steady flight would not be interrupted by vagaries of course. The engine was of the oscillating type. The frame construction was of steel, since aluminum was still expensive, difficult to machine, and impossible to solder.

But steel construction of the frame proved too heavy for the engine, and the model would not rise. Langley removed it and substituted another — a single-acting, oscillating engine, inverted and carrying both high- and low-pressure cylinders.

The first field trials of the model aerodrome with its new engine were held in 1893. Failure was immediate and complete. But Langley kept at it. In 1894 he built his fifth aerodrome, tested it, and failed again. Then he modified the design — mostly in the engine — and was rewarded with a flight that may have lasted for six or seven seconds. Here was a crumb of comfort, no matter how small. The next year, 1895, found Langley swiftly overhauling the disparity between the weight of his aerodromes and the power of his engines. His modified fifth machine he withheld from test until he could build a duplicate and experiment with both at once.

On May 6, 1896, Langley fired his aerodrome from a cata-

pult-launching mechanism on the banks of the Potomac River. The first machine rose at an angle of sixty degrees, stalled, and did a tail slide into the waters of the Potomac with its engine still going full blast. Langley put that failure down to a too great wing distortion. But the second machine fulfilled every hope of its indomitable inventor. It flew three complete circles and covered a distance of about 3200 feet in a minute and a half. Later in the year this aerodrome did even better, traveling 4200 feet — or three quarters of a mile — at a speed of 30 miles per hour. This was a genuine and heartening achievement.

Unlike many of his predecessors in the history of flight, Langley was not satisfied with one achievement. Stringfellow had been. Ader had been. Maxim had been. But Langley kept on going, and he kept on going in the face of an extraordinary rising public clamor against the silliness of building these toy machines and watching them fly. What sort of an occupation was this, they asked, for the head of the Smithsonian Institution — the National Museum of the United States? Why did n't he attend to the sober duties of the secretaryship and leave this sort of thing in the hands of the cranks and eccentrics to whom it belonged? These were only a few of the questions people asked one another. Langley retorted: "It has taken me, indeed, but a few years to pass through the period when the observer hears that his alleged observation was a mistake; the period when he is told that if it were true it would be useless; and the period when he is told that it is undoubtedly true, but that it has always been known."

Perhaps it was America's war with Spain that saved, for a time, the Langley researches. Between 1896 and 1898 he had

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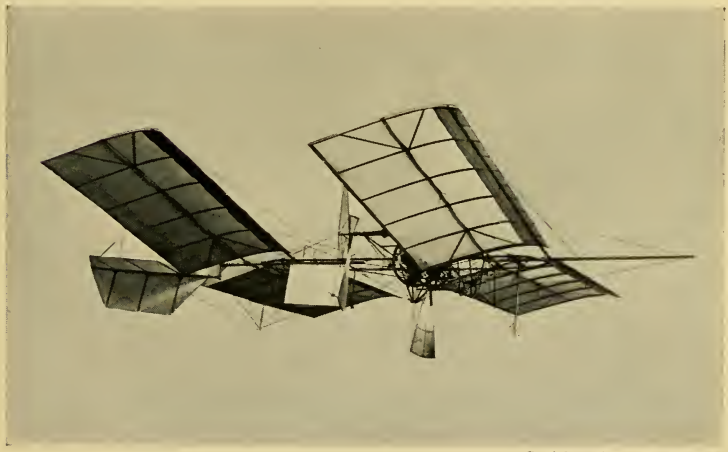
AERODROME NUMBER FIVE

One of Langley's Successful Steam-Driven Models (*Page 171*)



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AN AERODROME OF 1900

The Tandem Monoplane was Langley's Favorite Design
(*Page 171*)

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MANLY AND LANGLEY

Two Men Whose Genius and Persistence Deserved Success (*Page 174*)

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MANLY'S ENGINE

Modern Aviation Motors Are No More Remarkable Than This One, Built in 1902 (*Page 174*)

worked doggedly on his models with ever-decreasing funds. But in 1898, plunged suddenly into a struggle with Spain, the War Department of the United States felt that a full-grown, power-driven airplane would be a splendid thing for an army to have. It is not always that a country is blessed with a war department capable of thinking in terms of the same century in which it is fighting; but the United States of 1898 was, and as a result Langley received $50,000 as a Congressional grant to build a full-scale aerodrome. The work was to be carried out in secret.

By now the internal-combustion engine was actually doing duty in driving a few smelly and violently explosive automobiles on buggy wheels and thin tires down the dusty carpets that were country roads and the rough cobblestones that made up city streets. These were " horseless carriages " and were driven by vast collections of cogs, flapping belts, and machinery underneath the floor boards. They broke down remorselessly every few miles and were highly unpopular among all but the radical and flashy elements. Children jeered at them when they passed, at the dizzy speed of ten miles per hour.

But Samuel Pierpont Langley was a man of vision. He had the idea that one of these ridiculous inventions could be made to drive not only an automobile through the streets, but an aerodrome through the air. And by way of carrying out his contract with the government he ordered an engine which, for a weight of less than one hundred pounds, was to be guaranteed to develop twelve horsepower.

But this requirement was too much for the engine manufacturer and the contract was never made good. So Charles M. Manly, who for some years had been the devoted and gifted

assistant who had worked with Langley on all his aviation problems, set about to design and to build such an engine. He made himself, then and there, the inventor of the radial type of internal-combustion engine.

Manly's engine had five cylinders. On a brake test it showed 62.4 horsepower at 950 revolutions per minute. By itself, it weighed 2.2 pounds for every horsepower. When an ignition system, radiator, and gas tank were added, this figure increased to 3.6 pounds per horsepower. But even this was amazing for the year 1901, considering that the best engineering practice of the last almost thirty years has brought that figure which Charles Manly achieved in the second year of the century down scarcely lower than two pounds for every horsepower developed. Manly's design was a work of genius.

Finally Langley completed the aerodrome. Its weight was 730 pounds, its wing area was 1040 square feet. It had two propellers, and looked convincing.

To Widewater, Virginia, on one of the broadest spots of the Potomac, Langley took his aerodrome and the house boat from which it was to be launched. Along the top of this craft ran rails on which rested a "catapult car," held back against the push of great coiled springs by means of a heavy cable. When the cable was cut, the catapult car was to spring forward along the rails, run its course, and stop. The aerodrome was to pursue the course from then on in free flight, and it was to carry Charles Manly, engine designer, with it as pilot.

For the story of what happened that day let us rely upon George Rothwell Brown, reporter, whose exciting account appeared in the *Washington Post* for October 8, 1903:

At noon, it was realized the crucial moment was at hand. . . . Mr. Manly, wearing a pair of light trousers, canvas shoes, a life

preserver, and a pair of automobile glasses, climbed into the car. Two tugs, each with a portion of the Smithsonian force on board, were stationed at a distance from the ark. Manly started the naphtha engine. When all was ready he nodded his head to a helper, who fired a skyrocket warning to the photographers on the Virginia beach to be on the *qui vive*. The serious work of the experiment was about to begin.

A few yards from the house boat were the boats of the reporters, who for three months had been stationed at Widewater. The newspapermen waved their hands. Manly looked down and smiled. Then his face hardened as he braced himself for the flight, which might have in store for him fame or death. The propeller wheels, a foot from his head, whirred around him one thousand times to the minute. A man forward fired two skyrockets. There came an answering "toot, toot," from the tugs. A mechanic stooped, cut the cable holding the catapult; there was a roaring, grinding noise — and the Langley airship tumbled over the edge of the house boat and disappeared in the river, sixteen feet below. It simply slid into the water like a handful of mortar. . . .

In the ears of the chagrined and humiliated Langley there sounded the same horrid jeers that had driven William Samuel Henson into obscurity and death. It was a bitter day for him, but he kept his courage. Manly, at least, had not been injured. Together they fished for the aerodrome in the broad Potomac; dragged it up and carted it ignominiously back to Washington. The newspapers made funny comments. But the engine was intact, the frame was undamaged, and Langley and Manly resolved to try again. New wings and a new rudder would be needed. They set to work to supply them.

The second trial came on December 8, 1903, two months

and one day after the first failure. This time it was held at the junction of the Anacostia and Potomac Rivers, and General Randolph of the Board of Ordnance was among the official visitors.

At 4.45 in the afternoon the catapult-car cable was cut, and the aerodrome, its engine drumming perfectly, trundled across the track from stern to bow of the house boat.

Just what happened has never been clear. All we know to-day is that something once again went wrong with the launching mechanism. Apparently a rear guidepost dragged, bringing the rudder down to scrape on the launching legs. The rear wing crumpled up and collapsed, and when the catapult car reached the end of its journey and shot the aerodrome into the air it sank like a plummet into the waters of the Potomac, its engine still revolving without a missing beat.

Once more Manly was pulled out uninjured. But this time the Langley aerodrome had been wrecked beyond repair. Once again it was ignominiously fished out from the river, placed upon the house boat, and the remains of it carted back to Washington.

That was the end of the aerodromes. Funds were gone. Langley's spirits had sunk to the bottom of the Potomac with that second crash and had not come up again. The reaction of the Ordnance Department, which General Randolph had represented, was quite the same as that of the French army toward Clément Ader. It was " not prepared to make an additional allotment at this time for continuing the work."

Here was another great triumph for newspapers and their readers, who believed that these attempts to fly were in direct, impossible contradiction of all the laws of God and man. The *Boston Globe* cackled: " Perhaps if Professor Langley

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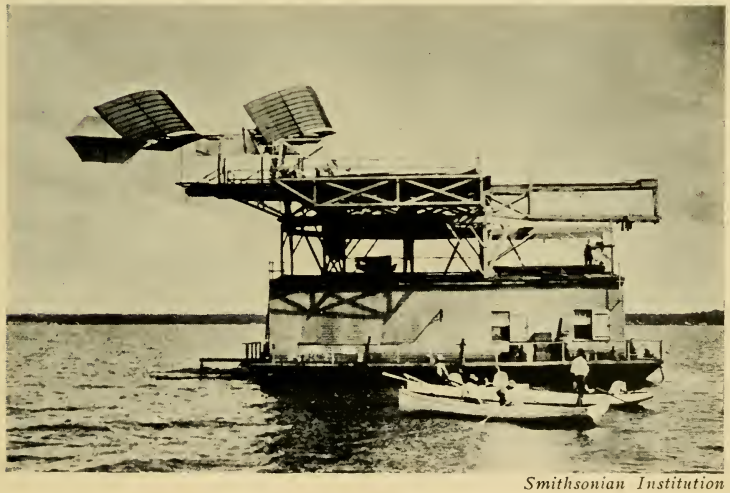
GREAT PREPARATIONS

Charles Manly Supervises the Building of the "Aerodrome"
(*Page 174*)



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ON THE CATAPULT

The Langley "Aerodrome" Just Before Its Launching (*Page 176*)

Smithsonian Institution

DISASTER

The Final Wreckage of Langley's Hopes (*Page 176*)

had only thought to launch his airship bottom up, it would have gone into the air instead of down into the water." And Ambrose Bierce wrote: "I don't know how much larger Professor Langley's machine is than its flying model was — about large enough, I think, to require an atmosphere a little denser than the intelligence of one scientist, but not quite so dense as that of two."

This babel of public ridicule rose in an ever-increasing volume around the ears of Langley, Langley's aides and sympathizers, and all men who continued to cherish the ridiculous idea that the air would support any mechanism more heavy than it.

Nine days later, on December 17, 1903, if the world had known, the chorus of jeers would have stopped as if a giant hand had been clapped over the foolish, jabbering public mouth. A "strange contraption" of wood and linen, glue and rubber, rose into the air from an awkward pair of skids and settled down with a jar twelve seconds later into the soft sands of Kill Devil Hill, at Kitty Hawk, North Carolina. The Wright brothers had flown.

XIX

THE IMMORTAL WRIGHTS

In the fall of 1878 the Reverend Milton Wright, Bishop of the Church of the United Brethren of Christ, brought home for the enjoyment of the two youngest sons in his family of five children a toy helicopter. If any date can be set at which the idea of flight first sprang into the minds of Wilbur and Orville Wright, this is probably it. "A toy so delicate lasted only a short time in the hands of small boys, but its memory was abiding," they wrote later.

When the small Wilbur and the smaller Orville were put to bed at night, they thought of the idea of flying. "Nothing," Orville Wright has said, "that ever actually happened to us was more thrilling than the *idea* of flying as we had it years before we had ever succeeded in leaving the ground."

Yet men of any worth are never contented with ideas only. Wilbur and Orville began with attempts to build toy helicopters themselves. The smaller models flew well. They were greatly surprised, however, to discover that the larger the model, the less successfully it flew, and they decided that success in flying would never come about through man-carrying helicopters. So they abandoned them and took to kite flying.

The Wright family lived in Dayton, Ohio. Wilbur demurred at going to Yale, and the science of aeronautics prof-

ited accordingly. He and his brother Orville set up a small bicycle shop and spent every moment of their spare time in thinking and experimenting with the idea of flight. Flight did not interest them for its commercial possibilities. They recognized quite well that these were large, but the lure of making money by exploiting new inventions never took much hold on either. Conquering the air began with them not as a business but as a sport.

In the year 1896, when Otto Lilienthal was killed, the Wright brothers, now in their early thirties, were puzzled to confront two radically different notions about heavier-than-air flight. One was the notion of Langley and Maxim, which took problems of stability for granted and sought only to apply power to gliding machines. The other was the notion of Lilienthal, Pilcher, and Chanute — that problems of stability were all-important and that it was futile to make any attempt to apply power until they were fully understood. The Wright brothers favored the second idea and went to work accordingly.

As fortune had it, the Wright brothers took up aviation when it most needed them. In the year 1900, when they completed their first glider, the science was badly in the doldrums. The machine of Clément Ader was an enigma, and his flight could be neither credited nor discredited. Lilienthal and Pilcher had been killed. Sir Hiram Maxim had spent $100,000 and abandoned his work. Octave Chanute was too old. Only Professor Langley still kept at it.

The very first machine which Wilbur and Orville built had novel features. They had sought to find some way in which they might vary the inclination of different parts of the wing so that they could make the wind act as a force to

restore balance which it itself had disturbed. This revolutionary idea, the "warping wing," came to Wilbur in 1899 when he was fingering the cardboard top of an inner-tube box. He warped it between his fingers and thought suddenly that he had hit on a plan of stability control for gliders. Orville agreed. The result, in somewhat changed form, is found on every modern plane as the aileron. This first glider had also an adjustable horizontal rudder placed in front of the operator.

The Wright brothers had the great gift of youth, something which Professor Langley had lost by the time his thoughts on aviation had reached any practical form. They began with unbounded enthusiasm, and in October 1900 were ready to test their first glider, which was designed to act as a man-carrying kite in winds of from fifteen to twenty miles per hour. But the first trial indicated that for this machine even stronger winds were necessary than those of Kitty Hawk. Since at this season of the year such winds did not seem to be forthcoming, the machine was flown without a man aboard and operated with controls by cords held on the ground. The strong, steady flight of the machine gave them immediate confidence that their new balancing system was a success.

The first glider had the very considerable wing area of 165 feet. And yet its lifting capacity, even in winds higher than twenty miles an hour, was too small. So in 1901 they built a second kite. This one had 308 square feet of wing area — larger than any craft which Lilienthal, Pilcher, or Chanute had ever flown. Chanute, who paid his first visit to Kill Devil Hill in 1901, insisted that the design of the machine was sound. Why, then, would it not fly? Wilbur was discouraged. "Nobody will fly for a thousand years," he said.

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FINIS

All That Was Left of Langley's Dream (*Page 176*)

Brown Bros.

THE BICYCLE SHOP

In These Humble Quarters of the Brothers Wright the Successful Idea of Heavier-Than-Air Flight Was Born (*Page 179*)

Wide World

THE GLIDING WRIGHTS

An Early Experiment on Kill Devil Hill (*Page 181*)

Brown Bros.

LAUNCHING GEAR

Wilbur Wright, at Pau, France, Stands Beside the Apparatus Used to Catapult Him Into the Air (*Page 181*)

Later he felt better and changed it to fifty. The brothers came to the conclusion that existing tables of air pressures were quite wrong.

One of the principal beliefs to which the Wright brothers held was that it was easy to ascend. The difficult and dangerous part of flying was to descend and still have machine and operator remain sound and healthy. Accordingly, they gave as much thought to their landing gear as to any part of the machine which was to sustain them in the air. Wheels, they thought, were not satisfactory; even the smoothest turf had humps and hollows into which they might skid. That is one reason why they chose the soft white sands at Kitty Hawk, on the narrow strip of land that fences off Albemarle Sound from the Atlantic Ocean. To land in these sands they equipped their first glider with long, slender skids resembling in appearance the runners of a dog sled.

The differences between many of their obviously correct discoveries and the beliefs of other people puzzled and disturbed both Wilbur and Orville Wright. They had taken up aeronautics as a sport. Now they found that if they were to go any further with it they must begin a detailed and exhaustive study of its scientific side. This they reluctantly began. Soon they found themselves buried deep in abstruse calculations. There seemed no other way to arrive at the truth about this puzzling and tricky " sport " ; other people, as Artemus Ward had once said, " know too many things that ain't so."

At Dayton, again, the brothers built a small wind tunnel sixteen inches square and six feet long. In it a variable speed fan produced a blast of air that would move at any speed they desired. Thus, with small wing surfaces, they could make

experiments to determine the effect of varying winds upon different wing designs. Their first experiments were on the comparative lift of oblong and square surfaces. They rediscovered the importance of the "aspect ratio" — that is, the ratio of the wing's length to its width. As a result, later gliders were given an aspect ratio of six instead of three, as before. On nearly fifty small-wing models they made countless experiments. The wise old Octave Chanute had told them that their gliding experiments were more successful than any others so far, but that had not satisfied the Wright brothers, who wanted actually to fly.

In September and October of 1902, Wilbur and Orville Wright made nearly one thousand glides. Several of them were the prodigious length of 600 feet or over, and some were made against winds as high as 36 miles per hour. Now and again the brothers were able to stay in the air over 60 seconds and often to remain soaring above one spot with no descent whatever. They were tumbled and bumped day after day, but they did learn — they served as thoughtful an apprenticeship to the birds as Lilienthal himself could ask for.

The story of the Wright brothers is strange and fascinating. They worked silently and with as little publicity as they could. "The only birds that talk are parrots and they are not birds of high flight," said Wilbur Wright in 1908 at a banquet in France where he was invited to speak. Knowing that most people would believe them mildly but hopelessly insane, the brothers kept their own counsel, consumed their own smoke, worked with an extraordinary application and absorption in their problems. They worked with unusual exactness, too. As a result, the story of their success is quite unlike the conventional struggle-and-hardship tales that one often reads.

It annoys Orville Wright even to-day to hear people who know nothing of the work at first hand emphasizing the heartbreaks and disappointments of his and Wilbur's early years. "There were almost none," he has said. "We made no practical tests until we had studied and checked everything theoretically and in the laboratory. As a result, the practical experiments usually worked."

By 1903, the Wright brothers felt that they had gone sufficiently far in their work to control stability. The time had come to make the bold forward step of applying power to gliding. But the mechanics of flight were desperately complicated. The machine would be moving forward; the air would be moving backward; the propeller would be turning sideways; nothing would be standing still. Wilbur and Orville had long discussions. First Orville would convince Wilbur, then Wilbur would reconvert Orville; then they would decide that both were wrong and that still more facts and figures were necessary. In this coöperation lay the secret of a success which neither brother could probably have achieved alone.

Then they thought: why should we not find information on water propellers from marine engineers and modify their conclusions according to the tables that we have calculated from our studies in the wind tunnel? The result was the discovery of an extraordinary and, for the marine engineers, a shameful thing. After one hundred years of use, the technical details of the action of the marine propeller in driving a ship through the water were still obscure and mysterious. It did drive the ship; they knew that. But no one in America had ever found time to study its complicated action completely. Once again these brothers who had entered on the

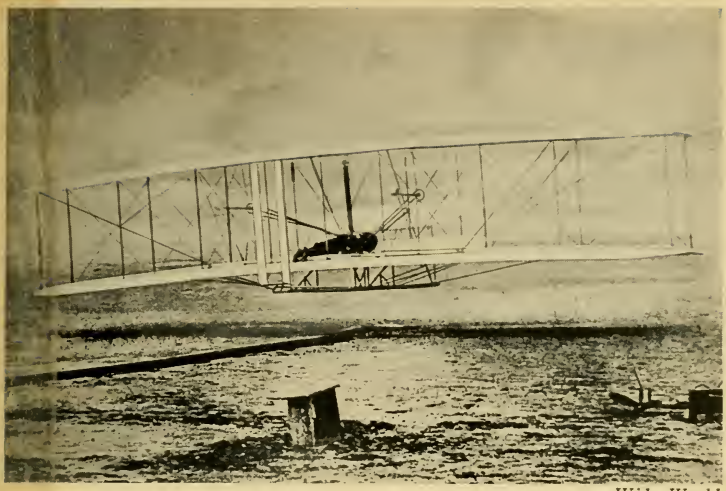
study of aviation as a sport found themselves deep in a scientific jungle that no one had ever been able to penetrate before.

At last, with their propeller difficulties better solved, they set out to find a motor that would give them a satisfactory source of power. They wanted an engine that would give them eight horsepower and weigh as little as 250 pounds. But they could not find one. Resigned now to the truth that no one else could or would help them with any of their problems, they turned to resolutely and built their own motor.

The Wright brothers did this in 1903, and they did it so well that, although they had expected their motor to develop eight horsepower, it actually gave them twelve.

Forthwith, knowing that they had excess horsepower, they added 150 pounds of weight to their plane by way of strengthening the wings. They were quite sure that their calculations on power and load were accurate. Into the strengthened machine they set their motor. It had four vertical cylinders; its stroke was 3.94 inches, and it was connected to two wooden propellers by bicycle chains and sprockets. (You will remember that the machine with which the Wright brothers were first familiar was the bicycle.) Its 1090 revolutions per minute were geared down to give a propeller speed of about 350.

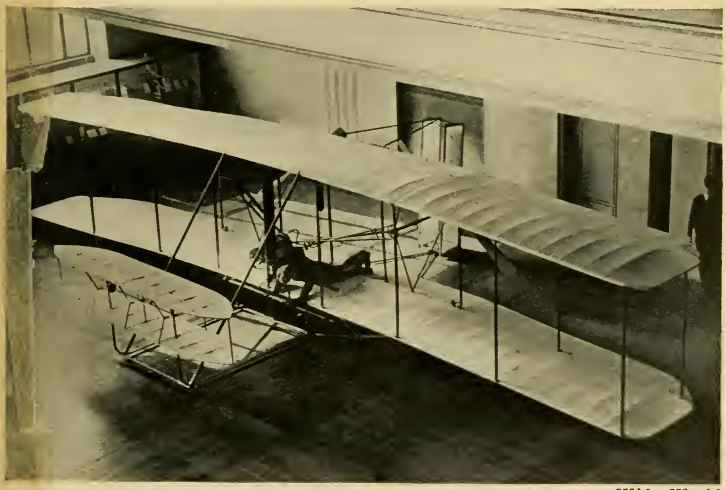
Then began a series of nerve-racking days. First they found a flaw in a shaft and sped to Dayton for repairs. After two weeks they returned again to Kitty Hawk. Then a new trouble arose. The bicycle sprockets insisted on coming loose from their shafts. The brothers overcame this difficulty on the spot by melting tire cement into the threads of the shaft. Next a tubular shaft cracked — Orville went to Dayton to



Wide World

FIRST FLIGHT

Thus It Was That Man First Left the Ground Under Power. (*Page 185*)



Wide World

THE FIRST SUCCESSFUL FLYING MACHINE

The First Craft of the Wright Brothers, Now Lodged in the Science Museum, London, England (*Page 184*)

THE FIRST SUCCESSFUL FLIGHT
OF AN AIRPLANE
WAS MADE FROM THIS SPOT BY
ORVILLE WRIGHT
EMBER 17, 1903, IN A MACHINE DESIGNED AND BUILT BY
WILBUR WRIGHT AND ORVILLE WRIGHT
THIS TABLET WAS ERECTED BY THE
NATIONAL AERONAUTIC ASSOCIATION
OF THE U. S. A. DECEMBER 17 1928
TO COMMEMORATE THE TWENTY-FIFTH
ANNIVERSARY OF THIS EVENT

Wide World

MEMORIAL

Orville Wright Stands Beside the Tablet That Commemorates His Immortal Achievement

build an entire new set. He returned on Friday, December 11, and on the following afternoon the Wright machine was ready for trial. Then nature interposed a delay — there was not wind enough for a take-off.

The following Monday was the fourteenth of December. The brothers took their machine to the top of a high sand dune, and there they tossed a coin to see who should be pilot on the first flight. Wilbur won. But on his first great try a restraining wire slipped. After a thirty-five to forty foot run along the homemade track from which the brothers proposed to launch it, the " strange contraption " jumped its rail, climbed a few feet, stalled, and struck hard on the ground, slightly damaged.

Three days later, on December 17, came Orville's turn.

They were simple days, those days in the early years of this century. Newspapers were enterprising, but publicity as it is practised to-day did not exist. Editors and other people knew in a vague, general sort of way that the Wright brothers were experimenting with a flying machine of wood, linen, glue, and rubber, but no one gave much heed. Only five people turned out, this day, to watch; the weather was too cold for most. Why should a crowd risk frostbite to watch two more crack-brained inventors obsessed with this foolish idea of making the air support something that was obviously too heavy for it? All but five of the people living within the vicinity of Kill Devil Hill thought the attempt not worth while. The five who were curious enough to appear were John T. Daniels, W. S. Dough, A. D. Etheridge, W. C. Brinkley, and John Ward.

These watchers had their just reward a few moments later. Like John Keats, they were watchers of the skies, and if some

new planet did not swim into their ken, something just as spectacular did.

For, dragged on an incline of Kill Devil Hill by a rope slung over a pulley and carrying a heavy weight, the odd contrivance of the Wright brothers started swiftly forward. It reached the end of the rail; then, unlike the unlucky aerodrome of Samuel Pierpont Langley, which had made its second ignominious plunge into the Potomac nine days before, the Wright plane, its motor roaring, its chains rasping over the bicycle sprockets, its two propellers whining in the air, kept on going. For twelve seconds it ploughed its way through the air in unmistakable power-driven, man-carrying, free flight. Twelve seconds. Take out your watch and count them off and think what those five men must have thought in those few instants in which man's flight ceased to be the mythology of Icarus, of Dædalus, and of Archytas, and became for twelve long seconds a fact.

The strange contraption of the Wright brothers had been the first machine to take off by its own power, to accomplish free flight, carrying a man, and to land again without being wrecked.

Other trials that day were successively better. On the fourth flight, the machine traveled 852 feet against a 20-mile wind and stayed in the air 59 seconds.

After that triumph (which had ended in an inoffensive crash) the machine was taken back to camp. It had done enough for one day. But the watchers had a sudden demonstration of the power of the wind and the hazards of flight. A gust of wind caught the machine and began tumbling it over and over on the sands. The bystanders rushed to help. John Daniels, husky and well built, clung to it desperately

like a cowboy to the back of a steer. By the time he and the others had tamed it, it was badly damaged.

But Wilbur and Orville Wright had other concerns that day. Their first thought was to get news of their success to their father. There was no commercial telegraph line at Kitty Hawk, but there was an official station of the United States Weather Bureau. To it, from Norfolk, there ran a slender pair of wires. The Wright brothers had made arrangements with the operator at the weather station to relay the news of success or failure to Norfolk and from there to Dayton. Now that success was in their hands, they rushed to the station and filed their message. This was not for the world to know. Official announcements would wait on even more conclusive success. Yet, within five minutes of the time their triumphant message had gone singing over the wires, a query came back to Kitty Hawk from a representative of the *Virginian Pilot*. Was this information for release to the press and might he have it? Wilbur and Orville bellowed No! The sounder at the other end obediently clicked off a dash and a dot, a pause, a dot, a space and another dot. Yet for all of that, under a seven-column heading, next day the *Virginian Pilot* carried a garbled story of what happened on the chilly afternoon before. Public interest rose, although to no very spectacular heights. The world did not realize the significance of the victory. It was to be almost four years before the triumph of the Wright brothers was to have any general acceptance by the public. The accounts were dull and matter-of-fact.

Nevertheless, there were people who wanted to watch the Wright brothers fly. Unfortunately the damage to the plane made flying now quite impossible — and it remained so

until the spring of 1904, when a new and improved machine was ready. This time, by the kindness of Torrence Huffmann, the brothers were able to continue their experiments only eight miles out of Dayton on Huffmann Prairie. For the first trial the brothers notified all newspapers, and a dozen reporters presented themselves. "Please do not make your reports sensational," the Wright brothers pleaded, "and please take no pictures. We want no crowds on the experiment ground."

But, like the small child who will not behave when company comes, the new Wright plane in the presence of fifty people refused to perform as expected. The wind was too light for a proper take-off and the engine was obstreperous. None the less the brothers tried it, only to fall ignominiously off the end of the launching track. That was enough for one day.

Next day a few of the more persistent reporters returned — and once again were disappointed. The plane glided only sixty feet and further trials were postponed for a complete overhauling of the motor. The reporters left, and made various statements to the effect that probably the Wright brothers had not learned how to fly after all.

Throughout the year 1904 the brothers continued their flights on Huffmann Prairie with a still larger machine. It had a span of 40 feet, a wing area of 600 square feet, and weighed 925 pounds. It would travel as fast as 30 miles per hour, and carry a wing load of $1\frac{1}{2}$ pounds per square foot. But stability, they found, was still a problem of many unsolved difficulties.

Lateral balance, for example, was still shaky. The brothers knew the relation of this to directional control — and then they had a flash of genius. They interconnected the control

of the vertical rudder with the warping wings so that both would work at once. That was the reappearance of the joy stick — and now for the first time, even though stalling remained difficult to avoid, the Wright brothers could execute a few simple manœuvres. On September 15, 1905, Orville made a turn in the air; five days later Wilbur made a complete circle. But in spite of difficulties, dangers, and close approaches to disaster, the year was one of slowly increasing successes, in which Wilbur and Orville increased the span of their flights to as great a distance as six miles. In all, during the year 1905 they made forty-nine flights — only half as many as they had made in the year before, but longer and surer.

Business negotiations took all the time of the Wright brothers during 1906. The experiments that had been begun as sport had now become not only a science but a business. No one officially or unofficially had ever lent the Wright brothers a sou for the carrying out of their experiments. They and they alone, with the help of their devoted sister Katherine, had borne the crushing load of the expense. In order to raise funds they had even sold a farm in Iowa given them by their father. What was to be done with their invention, now that it had been made? Should they sell it to governments, domestic or foreign? Should they dispose of it to private concerns? Or should they form a company of their own to develop it? An invention is like a baby — after it arrives someone must take care of it.

But in May 1907 the brothers resumed their experiments at Kill Devil Hill, to see if they could not meet the specifications of the United States government for a military plane. These insisted that a machine carry two men, be able to carry fuel

for 125 miles, travel at least 10 miles across country, and maintain a speed of 40 miles per hour. The machine which they used had seen service two years before at Huffmann Prairie, but now its operator sat, instead of lying prone. There was a seat also for the extra passenger. The motor, the radiator, and the gasoline reservoir were all larger and of improved design. For a military plane that would meet its specifications the government offered $25,000 — with $2500 extra for each mile per hour of speed in excess of 40.

But the brothers had by now sold their French patent rights to the Astra Company for $100,000 and it seemed advisable for Wilbur and Orville to work separately. Orville stayed at home to work with one machine; Wilbur journeyed to the home of aerostation, to show the slightly incredulous French nation that their attempts which had begun with Besnier in 1678 had now come to something.

His record in France was triumphant. On August 8, 1908, he made his first European flight at Le Mans. And on December 31 Wilbur won the Michelin prize of $4000 and into the bargain established a new world's record for endurance flight. His official time in the air was 2 hours, 18 minutes, 33 seconds, and his official distance was 77 miles, 2280 feet. Probably he flew 85 miles at least. Flights of more than half an hour had been uncommon before this.

Meanwhile, in America, Orville had been busy with the problem of flying a machine to meet the specifications of the government. On September 9, 1908, at Fort Myer, Orville, in the face of 10,000 scoffers, not one of whom believed "that contraption can possibly get off the earth," successfully flew an untried machine. On September 17, Orville again ascended. This time Lieutenant Thomas E. Selfridge, of the

C. H. Claudy

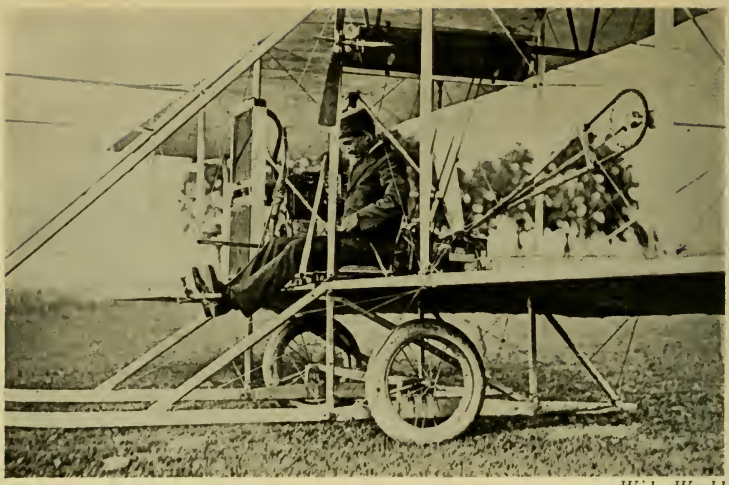
THE VERGE OF DISASTER

Orville Wright and Lieutenant Selfridge About to Take Off from Fort Myer (*Page 190*)

C. H. Claudy

FIRST CRASH

The Disaster Which Cost the Life of Lieutenant Selfridge. Inset, the Shattered Propeller That Caused the Wreck (*Page 191*)



Wide World

A LATE WRIGHT PLANE

Orville Wright Aboard a Machine Equipped With Wheels (*Page 230*)

Brown Bros.

THE THREE WRIGHTS

Between Orville (*left*) *and Wilbur Stands Katherine Wright, Whose Encouragement and Financial Aid Were Instrumental in Making Her Brothers' Experiments Successful* (*Page 189*)

Signal Corps, went along as an observer. Orville, in excellent spirits, promised the newspaper men that he would attempt to break his previous nine-minute passenger-carrying record. He took off. For five minutes the plane, its propellers new that day, performed faultlessly. Orville made three and one-half turns about the parade ground. Then spectators heard a jar, saw a splinterlike object fall to the ground. The machine tilted, hesitated, turned completely over, and fell one hundred feet, burying its nose in the ground at an angle of not more than ten degrees with the vertical. The hurrying, panic-stricken crowds reached a mass of wreckage to find Orville dazed and unable to speak intelligibly. Selfridge said only, "Take this thing off," and never spoke again.

Orville was painfully injured, but his one greatest concern was to discover what had happened. Study of the wreckage made it evident that the left-hand propeller had fouled in a tail guy wire which had worked loose. The propeller had snapped; the control mechanism had been demolished, and with only one hundred feet in which to manœuvre (safety was then thought to lie in low flight) Orville had been unable to bring his machine out of its fall.

"Selfridge is but one more name to add to the list of world martyrs in the conquest of the air," said Octave Chanute. "I deeply deplore the accident, but the work will go on just the same."

Go on it did. Never once did Orville show any fear of returning to the air. And in August 1909, with his elder brother watching his determined and fearless attempt, Orville Wright captured the prize offered by the Signal Corps for which his first attempt had all but cost his life.

XX

THE AEROSTATIC SPORTSMAN

In 1873 the wife of a wealthy Brazilian coffee planter presented him with their tenth child. This one, like the nine others who had preceded, was a son, and the delighted coffee planter named him Alberto. He was a frail child and grew up to be a slight man, but in skill, courage, daring, resourcefulness, and enthusiasm, few in the history of aviation can surpass Alberto Santos-Dumont.

There were six thousand laborers employed upon his father's vast plantation. Sixty miles of railroad track crisscrossed over it to carry coffee beans from the field through the various processes to which they must be subjected. At the age of seven young Alberto drove steam tractors in the fields; at twelve he pulled the throttles high up in the cabs of the Baldwin locomotives on the plantation railroad. Then, when he was fifteen, he saw his first balloon at Sao Paulo. Naturally he wanted to drive that, too. This he was denied.

In 1891, when he was eighteen, Santos-Dumont went to Paris. He was warmly devoted to the memory of the great Frenchman who had been the first to bring a real measure of control to the random invention of the brothers Montgolfier. He wanted to see the steerable balloons which had followed that of Henri Giffard — and he wanted also to drive a specimen of that fascinating new invention, the automobile.

In both desires he was at first disappointed. The French

had decided that Giffard's plan of aerial control was crack-brained and visionary. The sausage-shaped machine over which he, the brothers Tissandier, and Renard and Krebs had labored had vanished. Only the spherical balloon, with scarcely an improvement over the form Professor Charles had given it in 1783, remained. Could he, he asked a professional aeronaut, somehow be permitted to make an ascent in one of these stubbornly primitive craft? Yes, he could, came the answer; the price for a "brief ascent" would be twelve hundred francs. Santos-Dumont thought rapidly. If he did not enjoy the ascent, his money would be wasted; if he did, he would want to repeat the experience oftener than he could afford. He sighed, and spent his money for an automobile.

But even in this new art he found fewer raptures than he had hoped. Most people regarded the automobile resentfully, and the Agents de Police would not permit him to stop his new land craft at any place where it might cause a crowd to collect. He left Paris and went touring. He returned in 1892, hoping that the science of aerostation might have made some worth-while progress. It had not.

So Santos-Dumont bought a new automobile. Then, in disappointment, he returned to Brazil. On his next journey to Paris he had the luck to get in touch with La Chambre and his associate Machuron, the builders of the balloon in which Andrée had set out for the North Pole. These two displayed a much more reasonable attitude toward the young Brazilian's desire for flight. They would take him up for three or four hours, they said, for two hundred and fifty francs in cash and the expense of returning the balloon by rail. And so, in 1897, Santos-Dumont made his first flight.

Long before this, he had made known to Machuron, who now accompanied him, his belief in the idea of a steerable balloon. Machuron protested that it was quite impossible. And he all but convinced Santos-Dumont, for as they were descending at the end of their first trip the guide rope caught on a tree, and the balloon, held captive, was buffeted brutally. "Observe," said Machuron, "the treachery and vindictiveness of the wind." It was quite observable, Santos-Dumont admitted, and all but gave up.

None the less, the spherical balloon seemed to him at best a clumsy, useless craft. He pondered over the disappointments of Henri Giffard and regretted that the world seemed to have cast his invention aside. Then he thought: "Why should I not apply the petrol motor of the automobile to the driving of aircraft? Giffard had no such chance. Perhaps that was all he needed." The light weight and simplicity of the small motor which drove one of his tricycles impressed him, and he set about to build a dirigible that would fit it. These motors were poor affairs in the light of the present day. In 1895 they had not succeeded in driving an automobile faster than fifteen and a half miles per hour. Santos-Dumont nevertheless remained convinced that they would solve his problem.

He fitted two tricycle motors in tandem, one behind the other, on the same connecting rod and fed them by a single carburetor. Everywhere he cut down on weight, and finally achieved a motor that would supply $3\frac{1}{2}$ horsepower for 66 pounds. The cylindrical balloon, built to go with it, was $82\frac{1}{2}$ feet long, $11\frac{1}{2}$ feet wide, and had a gas capacity of 6354 cubic feet. He refused to use the usual network method of suspending his car and devised one which La Chambre

thought so dangerous that he could hardly be persuaded to construct it. Once this pigmy dirigible had been built, dynamometer tests in Santos-Dumont's shop showed that the motor seemed to apply a tractive force of twenty-five pounds to the balloon, and Santos-Dumont thought this good.

His first take-off, made in the Jardin d'Acclimatation, turned out to be disastrous. Santos-Dumont, who was always very sure of himself, blamed the advice of an old-time aeronaut and insisted that if he had not followed it he would not have gotten stuck in the trees as he did.

Two days later, on the same location, he placed his dirigible where he wanted it, started his little tandem tricycle motor, cleared the trees, and soared proudly off, to the applause of the open-minded but somewhat skeptical crowd. To his infinite pleasure, this brave and jaunty little sparrow of a man discovered that with his steering rudder, guide rope, and ballast he was able to make any kind of evolution he wanted — to right and left and up and down.

His exhilaration conquered his caution and he soon reached an altitude of 1300 feet. Here he was disobeying an injunction which he later put into words, to the effect that height was the enemy of the dirigible aeronaut; that it was not a bad plan to stay close to the tree tops.

As a result of this high altitude, the hydrogen in the bag expanded notably and a certain amount of it was lost. That was all very well — but how flabby would the bag get when Santos-Dumont began his descent? He could only hope that the air pump which he had attached to the engine, to pump air into the bag to take care of the loss in volume of hydrogen, would prove sufficient.

It did not — and while Santos-Dumont was still several

hundred feet aloft his dirigible began, in his own words, "to fold up like a pocketknife." His descent rapidly became a fall. Then, just as he resigned himself to death, he saw some boys flying kites on the turf of Bagatelle. He yelled to them to catch his trailing guide rope and run with it as fast as possible against the wind. They grasped his idea immediately and so reduced the velocity of descent that he was brought down safely. Santos-Dumont sadly folded up his diminutive airship, hailed a hansom cab, and drove, with the relics of it, back to Paris.

Very little of the instinct of fear went into the make-up of this young Brazilian. It never occurred to him to worry whether a *retour de flamme* — that is, backfire — in his motor might set fire to the hydrogen-carrying bag. This very thing happened to him once. He gleefully records that he extinguished the flames with his Panama hat and went on with his voyage. Thereafter he continued to insist that the exhaust from the engine was not a hazard of flight.

In 1899 he built another ship, which he called the Santos-Dumont No. 2. It was the same length as the first, but of a greater diameter and hence a greater volume and stiffness, the idea being to avoid the embarrassments of the first trip. On May 11, 1899, he gave it a first trial. The weather was bad and the bag was heavy with rain, but he went up just the same rather than waste the 7000 cubic feet of hydrogen which had been previously put into the balloon. The temperature of the upper air sank rapidly. A new air pump once again proved insufficient and the second balloon doubled up and came down just as the first one had done.

Now, by heaven, he would build a third! This time he made it only 66 feet long, but 25 feet in diameter, so that it

had a volume of 17,650 cubic feet. In it he could therefore use cheap illuminating gas, not expensive hydrogen. And on November 13, 1899, he was finally rewarded — the Santos-Dumont No. 3 made a completely successful flight and gave its 110 pounds of combined designer, owner, navigator, and crew the opportunity to practise aerial evolutions to his heart's content. He circled, rode ahead in straight courses, forced the ship diagonally onward and upward, and shot diagonally downward by the propeller force and the longitudinal movement of a ballast weight which tipped the nose up or down.

Thereafter Santos-Dumont settled down to aviation as a life work. He built his own hangars and shops at St. Cloud and set a force of workmen at the task of building the Santos-Dumont No. 4.

This ship went the logical limit in supplying discomforts for the aeronaut. It was really nothing but an air-going bicycle — for Santos-Dumont abandoned the conventional car and used a bicycle frame with a saddle and handlebars at the centre of a spiderweb of sustaining cords. He equipped it with a seven-horsepower, two-cylinder motor, and to make himself thoroughly uncomfortable he placed the propeller at the stem of the craft instead of at the stern, so that he would get the full draft of the tail race in his face. On September 19, this ship had a successful trial before the International Congress of Aeronautics — with Professor Samuel Pierpont Langley among those present. Shortly afterward Santos-Dumont managed to get his propeller speeded up to 140 revolutions per minute. When the resultant gale blew on him, he promptly contracted pneumonia.

He went to Nice to recuperate, and during his convalescence

a new idea occurred to him. Hereafter he would suspend his car from the gas bag by means of piano wire — and thus eliminate the cords which caused an air resistance almost as high as the resistance of the bag itself. On his return to Paris, he immediately set about constructing the Santos-Dumont No. 5 with this new refinement. The propeller, with a return of discretion, had been placed at the rear.

By now aeronauts had a new prize to strive for. M. Henri Deutsch, a wealthy petroleum refiner and a member of the Aero Club, had offered a prize of 100,000 francs to the driver of the first dirigible balloon which, between the first of May and the first of October in any year between 1900 and 1904, rose from the Parc d'Aerostation at St. Cloud, circled the Eiffel Tower (since 1889 rising above the historic Champ de Mars), and landed at the starting point within half an hour. The total distance was seven miles.

It was required by the conditions of the prize that anyone contesting for it must notify the judges twenty-four hours before his proposed flight. This was more unreasonable than the judges had intended, for not even in Paris could anyone tell what the weather would be twenty-four hours in advance. It was also awkward, said Santos-Dumont, with the exquisite courtesy of the South American, to convoke the judges at the one hour most favorable to such an attempt — dawn.

But on July 13, 1901, Santos-Dumont dared these objections, and at 6.41 in the morning he left St. Cloud on his quest. In ten minutes he had reached the Tower. In several more he rounded it and started back. Unhappily, a strong head wind suddenly sprang up and the dirigible got nowhere in the vicinity of the starting point again until the fortieth minute. Even at that, Santos-Dumont did not land where he planned.

The flight ended in a horse-chestnut tree on the estate of the Comtesse d'Eu, from which Santos-Dumont found it inconvenient to descend. The Comtesse, imbued with the doctrine of *noblesse oblige,* sent him his lunch in the tree.

The airship was only slightly damaged, and by August 8, having thanked the Comtesse and restored the ship, Santos-Dumont was ready for another try. He set off at 6.30 in the morning and beat his previous outward time in encouraging fashion. By the ninth minute he had reached the Tower. No sooner was he on the home stretch than he realized that gas valves were leaking and that he was losing hydrogen rapidly. He risked going on, but the balloon sagged so much that presently suspension wires caught and twanged in the propeller. There was nothing for him to do but to shut off his engine. Immediately he found himself at the same time falling and being blown back toward the Tower.

Santos-Dumont had never cared much for the Eiffel Tower. He had always wanted to close his eyes as he rounded it to shut out the vision of what might happen if a broadside gust caught him while he made the turn. But it was not the Tower against which Santos-Dumont grounded; it was the roof of the Trocadéro. As the ship bumped and scraped along, Santos-Dumont clung desperately to what he could find while the Santos-Dumont No. 5, having stood all it could in one morning, exploded. From their station at Passy, Paris firemen came and rescued him. That very evening work in the St. Cloud aerodrome was begun on the Santos-Dumont No. 6.

Into the new ship this enthusiast who would not accept defeat incorporated every feature that he had learned from his experience with the first five. The valves were designed to avoid any such accident as wrecked him on the Trocadéro.

The volume was to be 22,239 cubic feet, and the motor twelve horsepower. By October 19, 1901, all was ready for his third try at the Deutsch prize.

The weather was bad. Of the twenty-five judges, only five appeared, but these five happily were enough. Within nine minutes of his start, Santos-Dumont had not only reached but turned the Tower, and found himself for the third time on the home stretch. Again the winds distressed him. Again disaster almost overtook him when his capricious motor twice all but stopped. But this time triumph belonged to him. He landed at St. Cloud 29 minutes and 31 seconds after he had taken off — with a leeway of just 29 seconds left.

To the Prefect of Paris Police, Santos-Dumont gave three quarters of the money which came to him for the winning of the Deutsch prize. It was, he said, "for the deserving poor." The balance of 25,000 francs went to the employees who had done so much to help him. What need had the son of a wealthy coffee grower for prizes? Yet almost immediately another one came his way. The government of his own Brazil bestowed upon him 100 contos, which was the equivalent of 125,000 francs. And a great gold medal came, too. It showed, said Santos-Dumont, "my humble self led by Victory, and crowned with laurel by a flying figure of Renown."

He did not rest upon this laurel, but went on building Santos-Dumonts. His No. 7 he believed would solve most of the problems of aerial navigation.

Yet it was perhaps his No. 9, "the little runabout," of which he was most fond. And it is for his exploit in this that Santos-Dumont will also be long remembered. For in the early morning of June 23, 1903, starting from St. Cloud, he

sailed to the Étoile, rounded the Arc de Triomphe, "to the right, as the law directs," and continued down the Avenue des Champs Élysées on a level with the housetops. At the corner of the Rue Washington he cut off his motor. Servants seized the ropes of his little runabout and hauled it down. Santos-Dumont stepped jauntily out of his car, went into his own house on the corner, and upstairs for breakfast coffee from Brazil.

That feat, certainly, deserves to live.

But Santos-Dumont, having accomplished it, having been the first successful builder of a practical dirigible, and having shown himself an "aerostatic sportsman" of a high degree, suddenly became a violent and successful convert to heavier-than-air flight. He made his first attempt at heavier-than-air power flight in July 1906, by attaching his airplane to the gas bag of his Santos-Dumont No. 14 in the hope of giving it a flying start. The idea resembled Professor Montgomery's, but for Santos-Dumont did not work well. The plane flew only a few yards.

On December 23, 1906, he entered a competition for the Archdeacon Cup, to be awarded for the success of the incredible venture of flying 25 metres — which is to say, 82 feet. Santos-Dumont's box-kite plane looked flimsy, but the fifty-horsepower Antoinette engine drove the steel and bamboo frame resolutely ahead. It taxied a few yards, rose, and flew 40 to 50 metres in a rickety, staggering flight. The aviator cut the ignition and his plane came down so violently that it broke its front wheels and elevator. One more victory had fallen into the grasp of this slim but sturdy Brazilian. He had, in fact, so astonished the committee of scientists that they failed to measure the exact distance he flew, and gave him

credit for only the necessary 25 metres, whereas his total distance was probably 60 metres.

And so our aerostatic sportsman met with a new distinction. He was the first man in Europe ever to fly a heavier-than-air machine and the first man anywhere to hold an entirely public exhibition of heavier-than-air flight. He went resolutely on. In 1906 he held an official "world's record" by virtue of a flight of 690 feet in 21⅕ seconds. Early in 1909 he built his famous Demoiselle. It was fast and light, but hard to fly, and looked like a wreck without the formality of going through an accident. Santos-Dumont crashed often in it, but usually himself escaped injury. He would swiftly repair the ailing Demoiselle and begin again.

All in all, this amazing Brazilian spent $125,000 in furthering heavier- and lighter-than-air flight. Of his many unique designs he patented never a one. He lives to-day, a man of fifty-six, retired from the active world of aviation, which he left so notably richer for his contributions of money and of courage and of brains.

XXI

THE TRIUMPH OF THE DIRIGIBLE

While Lilienthal was serving his apprenticeship to the birds, while Pilcher was building his Bat, Beetle, and Hawk, while Chanute was busy with his multiple-wing gliders, and while Maxim was sweating with his steam chariot, another group of men were bent with equal determination upon following up the advantage that Henri Giffard and Dupuy de Lôme had finally obtained over the balloon. In 1897, the same year that saw Langley struggling with his model aerodromes, the world was astonished by the Schwartz airship — the first rigid dirigible ever built. It was 156 feet long, with a skin of aluminum (then just becoming a practical structural metal) eight thousandths of an inch thick. The ship was braced by interior latticework and carried separate gas cells. A two-cylinder petrol motor served for power.

In this surprisingly precocious ship, a German soldier whose name was Platz attempted an ascent from Tempelhofer Field in 1897. He got up successfully — and got down successfully, too, which was much more of a feat, for the construction of the ship was imperfect and the fugitive hydrogen found plenty of means for escape. Platz was both captain and crew. Four miles distant from the start, his ship became entirely unmanageable and began sinking, bit by bit, as the hydrogen wafted away. With the car not more than fifteen feet from the

ground, he watched his chance, jumped clear, and landed unhurt a split second before the dirigible crashed.

The dirigible was not so fortunate as its commander. The shock fractured its spine, and the high wind, which seems to delight in springing up where and whenever it can be embarrassing to a lighter-than-air machine, finished off the job. Schwartz must be regretfully scored with a failure, although he is also to be credited with foresight in the use of aluminum as a structural metal.

The year 1897 saw another failure. Two German students of lighter-than-air navigation, Baumgarten and Wolfert, had fitted one of the first Daimler internal-combustion engines to a dirigible balloon as early as 1880. Their craft had three cars. A passenger in the outer car produced an uneven load distribution when they attempted to ascend from Leipzig. The ship crashed, but no one was injured.

When Baumgarten died, Wolfert attempted to carry on. He made an ascent on June 12, 1897, from the same Tempelhofer Field, near Berlin, which had been the scene of the rising of the Schwartz rigid dirigible. This ascent, thought Wolfert, would certainly eclipse all previous records.

It did not. Instead, it eclipsed Wolfert himself and the passenger he carried with him. The dirigible, traveling with the wind, rose quickly to a height of 600 feet. But the design of the craft was imperfect. Exhaust sparks from the motor scorched the cloth envelope, and in a moment there came a tiny flicker which burned its way through the linen. Instantly the whole interior of the dirigible became a seething mass of flame. Wolfert and his passenger came to an end by fire even before their bodies struck the ground.

From the beginning, the names of pairs of brothers are writ-

ten large throughout the history of aviation. Montgolfier, Robert, Gerli, Tissandier, Lilienthal, Wright — these are outstanding names. There then appeared in 1899 the Lebaudy brothers — wealthy French sugar refiners, who, although they were neither scientists nor pilots, supplied the money to make it possible for Julliot, a gifted engineer, to turn his highly productive thoughts in the direction of aerostation.

Three hard years of effort showed, in 1902, the completion of his first ship. It was of the semirigid type. A heavy spar ran most of the full length of the craft and acted as a keel for the gas bag which swelled above it. From the keel also was suspended a car to carry the power plant and the navigators. This first ship was called the Jaune. It was 183 feet long, had a maximum diameter of 30 feet, and a gas capacity of 80,000 cubic feet. Its power plant was a 40-horsepower Daimler motor which drove two propellers. It could make a speed as thrilling as 26 miles per hour.

In the space of a few months the Jaune made 29 trips. Then, in November, it was wrecked by collision with a tree — which remains always to the aerial navigator what a reef is to a sea captain. But the second Lebaudy-Julliot ship was even more successful; was, in fact, accepted by the French government — the first dirigible to be approved for military service.

Which brings us to the man whose name, by all odds, remains the most famous in the annals of lighter-than-air achievement — Count Ferdinand von Zeppelin. He was born at Constance, in Baden, two years after Mr. Charles Green, with Monck Mason and Robert Hollond, made his great balloon flight from the Vauxhall Gardens to the astounded Duchy of Nassau. Zeppelin made his first aerial ascent in America — from St. Paul, Minnesota, in 1863.

Count Zeppelin had an illustrious and highly assorted military history. During the American Civil War he served on the Union side. Then, having returned to his native country, he became a cavalry officer during the Franco-Prussian War and eventually reached the grade of lieutenant general.

In 1898, Count Zeppelin retired from the army with the resolve to devote himself to the cause of lighter-than-air flight. The government was not interested in him. To the martinets of the Wilhelmstrasse, Count Zeppelin was only a visionary; so he organized a stock company, and with its capital of 800,000 marks he set about building the first of his series of famous airships. It followed the design of Schwartz in being a rigid ship. He used aluminum as a framework, but the framework was a structural device only; the task of supplying buoyancy to the dirigible was given over to separate linen bags, or gas cells, holding a total of 400,000 cubic feet of hydrogen. These resembled the water-tight compartments of a ship — one or more might be punctured without serious damage to the whole craft. No longer did an aeronaut keep all his eggs in one basket. Over all, the ship was 420 feet long; its greatest diameter was 38 feet. It was far and away the largest aircraft built to that time.

Two cars were rigidly attached to the framework. Each had a 16-horsepower motor. For forward motion, these were connected to the usual vertical propellers. But for lifting they could be connected also to horizontal propellers, placed under the envelope. In this peculiar and rather foolish arrangement Count Zeppelin was following the designs of the early submarines of 1885. As a further aid to manœuvring, Count Zeppelin supplied a sliding weight, normally

ZEPPELIN IV

The Car of One of Count Zeppelin's Early Designs on Lake Constance in 1906 (*Page 207*)

ELY'S TRIUMPH

The First Landing of an Airplane on a Battleship in 1910 (*Page 232*)

Brown Bros.

BERLIN TURNS OUT

One of Count Zeppelin's Early Craft Manœuvres Over the German Capital (*Page 209*)

Brown Bros.

COUNT FERDINAND VON ZEPPELIN

Germany's Lighter-Than-Air Pioneer, on the Bridge of an Early Sky-Liner (*Page 206*)

to be kept in the centre of the ship, but to be carried forward by a winch to aid descent or backward to aid ascent.

For the convenient housing of his dirigible, Count Zeppelin built a floating airship shed, which he launched on Lake Constance. This was a floating hangar, and the central part of the floor, built in the form of a pontoon, could be detached and towed out, carrying the airship. Count Zeppelin made it possible to turn the shed on the water in any direction to suit the wind — since if he did not do so a cross current might very well catch the dirigible and bend it around the doorway when the ship was halfway out.

It was the stabilizing mechanism which turned out to be the stumblingblock in the way of the first successful test of the new craft. At Friedrichshafen, on Lake Constance, in July 1900, before the dirigible LZ-1 had had a fair chance to show what it could do, the winch operating the sliding weight broke and the dirigible sagged in the centre like an old horse — so much so that the propellers could no longer turn. It made a speedy and involuntary descent, and gashed itself on the piling as it landed. Its best speed had been $8\frac{1}{2}$ miles per hour.

By September the LZ-1 had been repaired. On October 21 she made a second trip. This time she doubled her previous speed, and Count Zeppelin, who up to now had been condemned by his matter-of-fact compatriots as a ridiculous visionary, was hailed as a hero. He no longer found it necessary to say, "It disturbs me in my work to be considered a candidate for a lunatic asylum."

This was all very well and quite pleasant; unfortunately, however, the eight hundred thousand marks of Count Zeppelin's stock company had now been all used up. He decided to

capitalize his new-found reputation; he appealed to the public for more money, got it, and built the LZ-2. This had a capacity of 367,000 cubic feet and weighed nine tons.

Over the Bodensee on November 30, 1905, a second accident befell Count Zeppelin. He could not use the floor of his floating hangar; the waters of the Bodensee were too low. Therefore he mounted the LZ-2 on pontoons and towed it toward the centre of the lake. But a strong following wind had sprung up. The dirigible overhauled the motor boat and attempted to return the compliment by towing it. The towline kinked and tangled. Sharply the strain pulled the front end of the dirigible down. By now her commander had started her motors in an attempt to manœuvre her, but at just the wrong moment a gust of wind caught her and lifted her by the tail. She dived ignominiously into the lake.

Six weeks were needed for repairs after that. The second trial of the LZ-2 came on January 17, 1906. Her motors were highly efficient; in the eight years in which Count Zeppelin had been experimenting, the internal-combustion engine had become a really practical machine. The motors of the LZ-2 were just about the same size as those in the LZ-1, but they gave 85 horsepower instead of 16. And even though the lifting force of the hydrogen was too great, and the dirigible immediately rose straight up for 1500 feet in a high wind, her rudders and propellers brought her under control. She made a successful descent and her commander anchored her. During the night the wind reached gale proportions. There is one thing you cannot do with a dirigible — you cannot romp with it. The wind insisted upon romping, and before morning completely reduced Count Zeppelin's LZ-2 to a tangled mass of wreckage. Yet there had been encouragement in these first

two trials. If only 32 horsepower could produce a speed of 20 miles per hour, what would the LZ-2, with 170 horsepower, have done if she had ever had a fair chance? The dirigible idea looked good.

It looked so good that within nine months Count Zeppelin had built the LZ-3. By now the government, which in an earlier day had loftily dismissed Count Zeppelin and his romantic plans, watched the experiments on Lake Constance with a new and sober respect. The LZ-3 was highly successful.

The next ship, the LZ-4, showed further improvement in performance. She carried a triangular keel outside the envelope. She could carry enough fuel for sixty hours, and a pair of three-bladed metal propellers, fifteen feet in diameter, were driven by each of two Daimler Mercedes motors, of 110 horsepower each. No longer did the Zeppelin design include the horizontal propellers. A vertical rudder at the stern and horizontal elevators at the sides provided her controlling mechanism.

The best performance of the LZ-4 came on July 4, 1908. On this day she made 235 miles across the Alps to Lucerne and Zurich and returned again to her hangar on Lake Constance. All this she did within the course of one twelve-hour trip. Her average speed was 32 miles per hour.

On August 4 she set out for her twenty-four-hour flight, one of the tests she must pass before government acceptance. She left Friedrichshafen in the morning. It was planned that she should follow the course of the River Rhine to Mainz, and return across country — a round trip of about 600 miles. But on the afternoon of the first day motor trouble set in and a stop of three and a half hours was necessary for repairs. Later,

to attend the same ailing motor, a second stop was made near Stuttgart. Gas leakage was troubling the crew now, also. While the dirigible was anchored, a violent storm swept down, broke her loose from her moorings, and set her adrift, a derelict of the skies. Without control, she rose too rapidly. In the thinner air the swelling hydrogen burst the gas cells. She went up suddenly in one enormous plume of flame, and the metal wreckage of her fell in a tangled crash. She had been in the air for only three hours and fifteen minutes less than was necessary for her government acceptance, and had covered 378 miles.

The plucky fight of Count Zeppelin to conquer the air had roused German enthusiasm to a flame. A public subscription was started, and Count Zeppelin found himself with extraordinary rapidity in possession of ten million marks — about two million and a half dollars. Not only that; the Emperor Wilhelm II visited his headquarters at Friedrichshafen to see the LZ-3 — which was once again the head of the family, now that her elder sister had come to destruction. He saw her; he approved her; he decorated Count Zeppelin with the Order of the Black Eagle, and there was general enthusiasm. The Crown Prince was permitted to grace one of her trips and emerged unscathed. Before the end of March 1909, Count Zeppelin made a successful trip to Munich and back with four army officers as observers. The military authorities were satisfied and thenceforth the LZ-3 was known as "S.M.S. Zeppelin I."

By this time Europe was firmly set upon the course which was to bring about the World War in 1914. Germany, bristling with militarism, pledged itself to the idea of the Zeppelin dirigible as an engine of war, and Count Zeppelin, who only

fifteen years before had received nothing but governmental discouragement for his plans, now found himself looming large in the national life.

It is amazing to realize that although Count Zeppelin had by 1914 built twenty-six dirigibles, over one half of which had been destroyed by one accident or another, not a single fatality had ever resulted from their navigation. This, coupled with the remarkable improvements in design which every new model had shown, raised German enthusiasms to a high pitch.

As early as 1910, Count Zeppelin's dirigibles aroused public confidence to a degree which made the first aerial passenger service possible. The LZ-7 (the Deutschland) he himself piloted on June 22, 1910, from Friedrichshafen through Stuttgart through Mannheim through Cologne to Düsseldorf. The 300-mile journey was accomplished without a hitch. A luxurious central cabin with a restaurant made its appearance as the very first refinement aimed at making air travel compete, in comfort, with the land variety. The third trip, made with thirty-three passengers six days later, ended suddenly. The Deutschland was caught in a severe storm. The gasoline tanks ran dry, hydrogen began to leak, and the Deutschland landed in the Teutoberger Forest, a total wreck. The passengers made ground safely, down a rope ladder.

When fatalities did come, they came swiftly. The first accident which took life occurred in September 1913, when the fourteenth ship was wrecked over the North Sea in a sudden storm and its entire crew of thirteen drowned. Three weeks later, while the nation was still stunned by this catastrophe, the eighteenth ship exploded in mid-air, while manœuvring over Johannisthal, and killed every one of its crew of twenty-five. The cost of Count Zeppelin's triumphs was

high. Yet between 1910 and 1914 his Deutsche Luftfahrt Actien Gesellschaft operated a commercial service with four ships, and carried over 17,000 passengers more than 100,000 miles without more than a minor accident.

XXII

BLÉRIOT FLIES THE CHANNEL

Writing some time close to the beginning of the twentieth century, that indefatigable prophesier, Mr. H. G. Wells, said this: "The cost of the conquest of the air will be greater than that of the greatest war that has ever devastated the world." He could scarcely foresee the war which was to tear Europe to shreds at a cost beyond most people's imagination, yet he was not wholly wrong. The cost of conquering the air has run to millions of dollars; the martyrs to its winning are numbered by the thousands — and the end is not yet.

For a time the Wright brothers had the aerial battle all to themselves. For almost three years the name of no one else appears in the annals of heavier-than-air flight. The world sat by in inexcusable ignorance.

But in 1906 the irrepressible Santos-Dumont broke out with a heavier-than-air machine and succeeded in flying for eight seconds. It was the first public demonstration and that, somehow, broke the spell. Once again the nation which forged to the front was France.

The man to whom all credit should go as the real transplanter of aviation to European soil — where it had always flourished most — was Louis Blériot, born in 1872 at Cambrai. He had begun his studies of flight in the same year as had the Wright brothers — that is, 1900. In this year he built a

flapping-wing model, which came to no good end. Later he experimented with a Voisin biplane glider over the Seine. By 1906 he had built four biplanes of his own design, all of which had remained resolutely on the ground. Blériot gave up the biplane design and thereafter built monoplanes.

In March 1907 he completed the first one, and on April 5 he managed a flight of six seconds — half as long as that of the Wrights four years earlier. Then he wrecked his machine, but managed to escape unhurt. Swiftly, he built another — this time a tandem monoplane along the design of Samuel Pierpont Langley. It served him ill. Shortly it, too, was a total wreck.

Blériot's seventh machine brought him his first measure of success. He built it within thirty days after his previous accident and achieved some good flights with it — actually succeeding in making a turn with the machine. But December saw the wreck of this one also.

Blériot learned from his crashes. He built an eighth machine and on July 6, 1908, flew it for eight and a half minutes — a great improvement in time over anything he had previously accomplished.

But in all this time Blériot had a rival in Henry Farman, an English painter, who had become one of the champion bicycle riders of France and was famous for his steady nerve and his great endurance. The automobile had found one of its earliest enthusiasts in him. He opened a motor-car business and then went into racing. Naturally, when a new and faster mode of travel presented itself, he was swift to take it up. Farman had excellent success. On October 15, 1907, in a biplane built on the box-kite principle by Voisin, he made his first flight, of 935 feet. Ten days later he almost tripled this

record and succeeded in the difficult task of making a turn successfully. On March 29, 1908, he carried the first passenger, Leon Delagrange.

In July Farman won a $2000 prize for a flight of thirteen miles. In September he set up a speed record of forty miles per hour in a flight lasting forty minutes. Then, on October 30, he added further to his illustriousness; he made the first actual cross-country flight in Europe — a distance of seventeen miles, from Bouy to Reims.

One day after Farman's flight, Blériot took up the challenge. He flew from Toury to Artenay and back, a total distance of eighteen miles, making two landings on the way. Five days later he sought to do it again. In a fog, he collided with a tree and wrecked his eighth monoplane, but, as in all his previous accidents, he escaped with only minor hurts.

By now a healthy and vigorous rivalry in the air was springing up in France. In 1909, on July 18, Louis Paulhan achieved a European altitude record by mounting 450 feet. And two days later another cherished rival of Blériot, Hubert Latham, who had previously achieved an endurance record of one hour and nine minutes, set out on the ambitious attempt to realize his dream of flying the English Channel. The *Daily Mail* had offered a prize of £1000 to the first man who would accomplish this feat.

At Sangatte, on the French coast halfway between Calais and Cape Blanc Nez, Latham built a shelter for a plane. To this he brought a light Antoinette monoplane mounted on wheels. He had no idea whether this plane would sink or float if it struck the water, and no one yet had worked out the buoyancy problems for planes not flying over land. Latham did not care. He expected to land in England. On

Monday, July 19, 1909, at 6.20 in the morning, a signal gun announced that he had started, and a wireless message was flashed to Dover that he was on his way.

Every condition was favorable. Latham soared at once to a height of 900 feet — already doubling the official altitude record that Paulhan had made only two days before — and sped swiftly away. He vanished into a cloud, and the French torpedo boat Harpon trudged after him. Latham emerged once from his cloud, roaring on toward Dover, and vanished again.

Later in the morning the Harpon came back, bringing M. Latham along — like Lunardi, wet, but not too disheartened. His engine had failed when he had covered eight miles of the twenty and while he had been making a speed of forty-five miles per hour. The tug which had rescued him found him sitting, the picture of nonchalance, on top of his fuselage, smoking a cigarette — for the plane had floated!

Louis Blériot immediately entered the contest, which now became a race. While Latham sped to Paris for a new plane, Blériot appeared at Les Barraques, near Calais, with his eleventh monoplane. For several days, storms interfered with any attempt at a take-off, which allowed Latham time to return to his own headquarters, triumphantly ready.

At four o'clock in the morning of Sunday, July 25, Blériot hobbled to his plane on crutches. He had been injured in a gasoline explosion only a short time before and an abscess had developed in one of the burns on his feet. Not for a minute would he let this interfere on the day that promised for a good take-off. First he flew two circles to test his three-cylinder twenty-five-horsepower Anzani motor and landed. "In ten minutes I start for England," he said. And at 4.35

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START

Hubert Latham Leaves Sangatte on the First Attempt to Fly the English Channel (*Page 216*)

Brown Bros.

FINISH

Latham's Second Attempt to Cross the Channel Comes to Grief Within Sight of the Dover Cliffs (*Page 219*)

Brown Bros.

ANOTHER START

Louis Blériot Leaves France Behind on His Cross-Channel Flight in 1909 (*Page 217*)

Brown Bros.

ANOTHER FINISH

The Immortal, if Somewhat Draggled, Blériot (*middle of rear seat*) *Rides to Dover for Breakfast After His Successful Channel Flight* (*Page 216*)

he was off. He rose one hundred feet and headed for the chalk cliffs of Dover. Once in the air, Blériot was almost wholly at the mercy of chance. He had no means of telling direction other than his own sight. If a fog blew up, he would be hopelessly lost. A change in wind might well blow him out to the North Sea. His one precaution against disaster had been to fit an inflated rubber cylinder five feet long into the middle of the fuselage to ensure buoyancy for the plane in case it fell into the sea. What did he think? We have his own record for that: —

"I begin my flight steady and sure toward the coast of England. I have no apprehensions, no sensations — *pas du tout* — not at all. The Escopette [French torpedo boat assigned to follow him] has seen me. She is driving ahead at full speed. She makes perhaps twenty-six miles an hour. What matters it? I am making at least forty-two miles an hour. . . . Ten minutes are gone. I have passed the destroyer and I turn my head to see whether I am proceeding in the right direction. I am amazed. There is nothing to be seen — neither the torpedo boat destroyer nor France nor England. I am alone. I can see nothing at all. I fly westward and reach Shakespeare Cliff. I see an opening in the Cliff. . . . Once more I turn my aeroplane, and, describing a half circle, I enter the opening and find myself again over dry land. . . . In two or three seconds I am safe upon your shore. Soldiers in khaki run up, and policemen. Two of my compatriots are on the spot. They kiss my cheeks. The conclusion of my flight overwhelms me."

Blériot had flown the English Channel and landed in North Fall meadow, behind Dover Castle, covering the twenty miles in thirty-seven minutes. The honors which Jean-Pierre

François Blanchard had won for France one hundred and twenty-five years before, Louis Blériot had made secure. The English arose without their usual Sunday morning breakfast to give him a reception which almost suffocated him. Blériot had just finished breakfast at Dover when customs, health and immigration officers pounced on him. Had he any dutiable goods on board? He had not. There were more questions. Finally he was, with magnificent solemnity, given clearance papers: "I hereby certify that I have examined Louis Blériot, master of a vessel 'monoplane' lately arriving from Calais, and that it appears by the verbal answers of the said master to the questions put to him that there has not been on board during the voyage any infectious disease demanding detention of the vessel, and that she is free to proceed."

His plane was taken to London by train, and within the next four days 120,000 people saw it. Blériot had had fifty accidents in the course of learning to fly. First to last, his experiments cost him $100,000. Every accident, every expense, he felt, was now amply repaid to him by the joyous crowds of London. A monoplane, carved in stone, is sunk into the site of Blériot's landing as a memorial to that flight.

Hubert Latham was the first to send congratulations to his rival. He had intended to make another try on the same day and had left orders to be called early. Somehow, however, he slept too late, and by the time he was ready Blériot had been gone twenty minutes and a twenty-five mile wind was blowing. Latham yearned to start none the less. The officials of the Antoinette Company, who built the plane, refused permission.

Poor Latham. Two days after that he started again — this time at six o'clock in the evening. On this attempt he came

within a mile and a half of the Dover Cliffs — and then his engine failed again. A British warship picked him up and put him aboard the French destroyer Escopette. He had already lost the thousand pounds — it is too bad that he was also to lose the fame of a successful crossing.

Planes were progressing. A Channel flight would have been foolhardy in 1908; it was a courageous achievement in 1909; and it was an old story in 1910 when Jacques de Lesseps, son of the great engineer who built the Suez Canal and was beaten by Panama, accomplished it. There was hardly an ounce of enthusiasm for this second crossing. The answer is easy. In the seven years since the Wright brothers first made their faltering, twelve-second flight, the airplane had made incredible strides. Now the altitude record was 11,474 feet; the duration record was 8 hours, 12 minutes; the distance record was 362.7 miles; and speeds had gone to over 65 miles per hour.

But 1909 saw many other interesting developments. It saw, for example, the first great airplane meet ever held. This was a landmark of flight — the first exposition of aviation that the world had seen.

It opened on Sunday, August 22, 1909, at Reims. The first day saw twelve machines all in the air at once. This was unheard of; this was unprecedented. The watchers of the skies gasped with amazement. To what new extravagances would not this new art go? There had been much rain on the day before and the field was a sea of sticky mud. It lent color to the event of the first day, which was a race on a triangular course. The clinging mud stuck to the wheels of the machines on the take-off and made the event look rather like a combination between an aviation meet and a potato race.

Among the entrants were Guffroy, who could not get off the ground; Blériot, who flew one leg of the course before grit in his carburetor forced him down; Latham, who had a plane numbered thirteen and a recurrence of the engine trouble that was always clouding his life; Captain Ferber, who, like Guffroy, could not take off; and Lefebvre, who, in a Wright biplane achieved success, and made the $6\frac{1}{4}$-mile course in nine minutes with a twenty-mile-per-hour wind blowing.

Throughout the week, thrill was piled upon thrill for the watchers, and record after record was broken. Lefebvre would set one record on the triangular course; Blériot would beat it. Then Glenn Curtiss, representing America at the meet, would beat Blériot. On Thursday, Latham made 43 miles in 62 minutes in the morning, and $96\frac{1}{2}$ miles in 2 hours and 13 minutes in the afternoon, not stopping because of the steady and persistent rain which came just before he broke the record, but keeping on until his gasoline tank was empty. There were glory and prizes for all. Henry Farman won the Grand Prix de Champagne by doing 112 miles in 3 hours, 4 minutes, 56 seconds. Latham was second and Paulhan was third. These three speeding machines were supplemented from time to time by three friendly crows, who had nothing in particular to do and picked out the exposition grounds as a scene for their activities. With a happy impartiality, the crowd cheered them as wildly as it cheered its heroes. On Saturday, Glenn Curtiss won the Gordon Bennett cup by going 20 kilometres in 15 minutes, 50.6 seconds. Blériot was only 5.6 seconds behind. And Farman finally won the passenger prize by carrying two people six miles in 10 minutes, 39 seconds.

On the last day, Delagrange's propeller broke in mid-air

and he narrowly escaped serious accident. Curtiss set up a new official speed record of 50 miles per hour. Latham sought for altitude and claimed 1200 feet; the more conservative judges gave him the prize and told him that he had been up 500 feet.

And, to cap the climax of excitement, Blériot's plane caught fire and burned when the carburetor flooded upon his landing. The tanks burst, and he was badly burned.

But even this disaster had no effect upon the wild enthusiasm of the crowds. Latham was their darling. Blériot was revered for his plucky fight against odds. Lefebvre was applauded as the comedian of the meet. Finding himself entered with a machine too slow and too weak to compete, he set out to make himself the comic relief of the exposition. By all accounts, he did it nobly. He would zoom at the horses of the cavalry troop whose task it was to keep people off the field. The more they reared, the more cursing sergeants they flung into the dust, the more the crowd enjoyed it. They were happy also when Lefebvre's plane rushed the photographers who were trying valiantly to record priceless history on their ground-glass screens.

So, in a magnificent spirit of holiday frolic, ended the Reims meet. Thirty-eight planes had been entered — thirty-six had flown. For all the juvenile quality it seems to have to-day, it went far toward stimulating the development of aviation. England and Germany, consistent laggards in aviation as earlier they had been in aerostation, were given a sharp prod. As a result of the Reims meet even Germany set about building her first power-driven heavier-than-air machine.

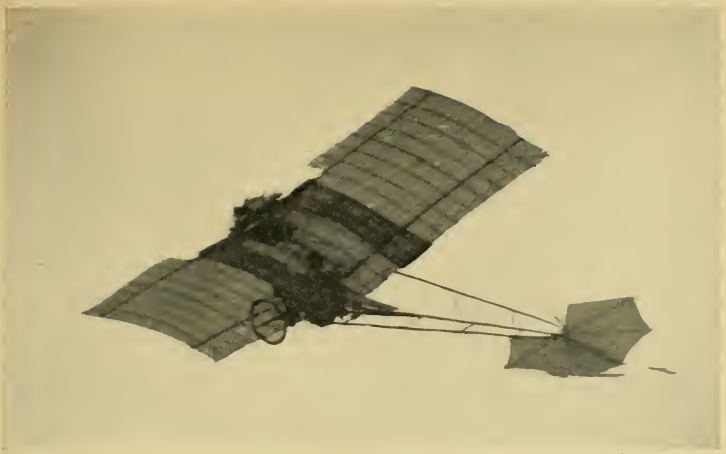
The commercial possibilities of aviation had now very definitely begun to occur to people who had heretofore regarded it

as a sport. As early as 1906, the London *Daily Mail,* which has always had a very free way of offering prizes for some new aviation feat, suggested that it would be glad to give £10,000 to the first person who would fly from London to Manchester within twenty-four hours. The distance was 183 miles, and contestants could stop when and where they liked, as long as they accomplished the distance in the required time.

It was not until 1910, the year after the Reims meet, that anyone felt intrepid enough to try this hop. Then an Englishman, Claude Grahame-White, undertook it. At 5.19 on the chilly morning of April 23 he took off. He came close to Lichfield, 117 miles away, with no trouble, but before he could go farther a gale sprang up. This eliminated, once and for all, any possibility that the trip could be completed in twenty-four hours. Next day, to increase Grahame-White's annoyances, the wind tipped his plane completely over. It was carted back to London for overhauling.

Meanwhile, Louis Paulhan appeared on the scene, anxiously eyeing the same £10,000. Both his machine and that of Grahame-White had been built by Henry Farman; it was thus up to the superior pilot to prove his skill. Paulhan, without even a trial spin, hopped off at 5.31 on the bitter-cold afternoon of April 27. At first he followed a special train; then he guided himself by the railroad tracks, which had been whitewashed at branch frogs to show which of two diverging routes was the correct one to follow. He roared along for 117 miles, landing at Lichfield.

At six o'clock of the same evening, Grahame-White heard that Paulhan had taken off. By 6.30 he was off in hot pursuit. He made 60 miles before darkness forced him down at Roden, leaving Paulhan still 57 miles ahead.



Brown Bros.

THE DEMOISELLE

The Diminutive Santos-Dumont Flies His Famous and Equally Small-Scale Plane, Following His Many Lighter-Than-Air Triumphs (*Page* 202)

Brown Bros.

LONDON TO MANCHESTER

The Victorious Paulhan Halts at Lichfield by Night in Course of Winning the Trophy of the Daily Mail (*Page* 222)

Brown Bros.

IMPROVISED HYDROPLANE

A Canoe, Lashed to the Bottom of an Early Wright Plane, Served to Make it an Amphibian (*Page 189*)

Brown Bros.

FLIGHT OVER WATER

Wilbur Wright, in His Canoe-Amphibian, Flies Over the Hudson River, at the Hudson-Fulton Celebration in 1909 (*Page 230*)

Ten thousand pounds is a great sum, and was greater in 1910. Grahame-White made a desperate attempt to trump Paulhan's ace by starting at 2.30 the next morning. It was still dark, and no one had ever flown in the dark before.

Yet Grahame-White accomplished it. With the aid of automobile headlights he got his rickety plane into the air and went roaring after Paulhan. At 4.14 in the morning he came down at Lichfield for gas — only five minutes after Paulhan had left there. But his robust daring did him, in this instance, no good. Londoners read at their breakfast table that morning, perhaps with a certain sadness, that Louis Paulhan had won the £10,000 offered by the *Daily Mail,* by virtue of having landed in Manchester at 5.32 on the morning of April 28, having completed the run of 183 miles from London within the space of twenty-four hours and in a flying time that totaled only 242 minutes.

XXIII

THE AWKWARD AGE OF AIRCRAFT

In the years between the aviation landmarks supplied by the Aeronautical Exposition at Reims in 1909 and the outburst of the World War in 1914, the record shows great progress and little glory. The great pioneers, successful and unsuccessful, had done their part. The airplane was now engaged in the more prosaic job of establishing itself. It shortly reached the awkward years of its adolescence. It outgrew the meets and expositions of its early youth — and it found itself too feeble and uncertain for commercial use. The business men of the time had no great yearning to put their dollars into the development of aviation; when you think of the planes they knew in the days before the war, you can scarcely blame them. Whereas only six men, of whom Otto Lilienthal was the first, had been killed by heavier-than-air accidents from 1896 to 1910, twenty-seven men were killed in the year 1910 alone. But this was in a period when over one thousand men had learned to fly, and although twenty-seven lives may seem a high price to pay in one year for the conquering of the air, remember that in that same year ninety people were killed in mountaineering.

But the romance of pioneering had far from vanished. In the midst of the more matter-of-fact inventors who had now taken away the mantle of glory from the pioneering aero-

nauts of an earlier day there arose suddenly a figure of romantic picturesqueness. He was Walter Wellman, journalist and explorer, and he proposed to fly to the North Pole in a dirigible.

The proposal was not entirely new. Salomon August Andrée, a Swedish engineer, set out for the Pole on July 11, 1897, from Danes Island, Spitzbergen, in a free balloon. From the expedition one carrier pigeon eventually returned with a message which read: "13th July, 12.30 P.M. 82.2° N.L. 15.5° E. Long. Good journey eastwards, 10° south. All goes well on board. This message is the third sent by pigeon — Andrée." And from that day to this no word has ever come — although in 1901 two citizens of Kankakee, returning from a trip to the Hudson Bay country, reported that Indians in the spring of 1900 found the bodies of two white men beside the basket of a balloon nine hundred miles north of Moose River. Their story was never authenticated.

Exploration came naturally to Walter Wellman. His first taste of polar hardships had come in 1894 when he was wrecked on a Norwegian ice breaker at Spitzbergen. In 1906 — in the days when Admiral Peary was straining every effort to reach the Pole — Wellman tried a dash by dog sled, but accomplished nothing beyond convincing himself that a leap through the air would be much easier than a trip over the rough, tumbling pack ice. The earlier disaster to Salomon Andrée did not disturb him. He went to Paris and had built for himself a dirigible which he called the America — 185 feet long, with a gas capacity of 258,000 cubic feet. His engine would develop between 70 and 80 horsepower.

By mid-1907, Wellman was ready to start for the Pole from

Spitzbergen. Not until September 2, however, did the remorseless northern weather give him an opportunity for as much as a trial trip. In that month, late as it was, Wellman grimly ordered, "Head her north."

North she was headed. But soon she struck a violent snowstorm, and three times came so close to complete disaster that Wellman had no alternative but to land on the ice, deflate his ship, and salvage as much of it as he could. He returned to Paris.

On August 15, 1909, Wellman with three companions set out once again from Virgo Bay, Danes Island, for the Pole. This time the weather was fine, and if the America had found it possible to maintain her trial speed of twenty-five knots he would have had no trouble in making the Pole in thirty hours. But after he had traveled only forty miles the leather drag rope broke; the America shot upward into the clouds and became almost unmanageable. That was the end of the second attempt.

Meanwhile, Admiral Peary discovered the Pole.

Wellman had no desire to play second fiddle in discovery. He promptly abandoned his attempts for polar flight and instead took up the idea of a transatlantic voyage which Charles Green and John Wise had suggested so many years before. He rebuilt the America for her new purpose — increased her length to 228 feet and her gas capacity to 350,000 cubic feet. He gave her two motors and placed a detachable lifeboat in her car. This time he made his guide rope of steel. It weighed two tons, and along the length of it were fastened drums of gasoline (to be used as fuel also) to add to its total weight.

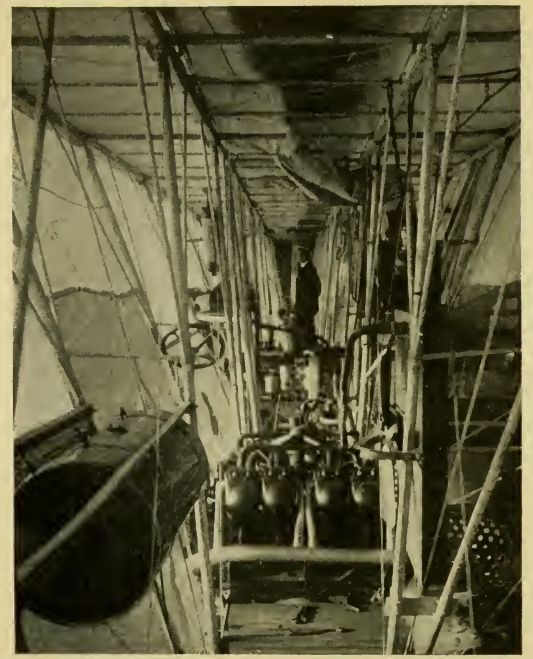
Wellman set out on his brave voyage on October 15, 1910,

DIRIGIBLE TO THE POLE

A Photograph Taken at Spitzbergen in 1909 of Walter Wellman's Dirigible (*Page 226*)

THE AMERICA

In This Dirigible Walter Wellman Sought to Cross the Atlantic in 1910 (*Page 226*)



Brown Bros

INSIDE THE AMERICA

The Interior Maze of the Dirigible in Which Walter Wellman Hoped to Reach First the Pole, Then Europe (*Page 227*)

Brown Bros.

RESCUE AT SEA

Wellman and the Crew of the Abandoned America Reach the Rescuing Ship Trent in Safety off Hampton Roads (*Page 228*)

at eight o'clock in the morning from Atlantic City, New Jersey. He carried a crew of six and a mascot in the form of a small gray cat. This one enjoyed its position no more than had any of its great-great-great-grandfathers who had been among the first passengers in hot-air balloons. It howled so mightily when the motors were started that the crew tried in mercy to lower it over the side in a bag and drop it into a waiting motorboat. This attempt did not succeed, so the cat went along, and, being fed biscuits, withdrew some of its objections.

The America pushed her way slowly northeast. The wireless which Signor Marconi had invented only a few years before was used to keep her in communication with the shore. For the first time, a ship of the air had this benefit.

When the America was only eighty miles out, a motor stalled with sand in a bearing and the rest of the day was unhappily wasted. As the cool of evening came on, the hydrogen contracted and a good deal of precious fuel for the engine had to be thrown overboard to compensate for the loss in buoyancy. During the course of that first night there almost occurred an accident which would still be unique if it should happen today — the America was all but rammed by a schooner, and would have been if the helmsman had not seen her huge shadowy bulk just in time.

By next morning the America was two hundred and fifty miles from Atlantic City, over Martha's Vineyard. Gradually she made her way to sea, half with purpose, half drifting. The wind was gusty and the outlook for success was poor. The guide rope, which Wellman called by the fancy name of equilibrator, jumped fifty feet from wave crest to wave crest and put a terrific strain on the car with every jerk.

Gloomily, the crew fried ham and eggs on a little gasoline stove in the lifeboat.

By noon on Monday the America had drifted southward again until she was four hundred miles east of Hampton Roads. All hands were willing to abandon ship and clung to it only because they were afraid that if they lowered the lifeboat it would be crushed by the thrashing equilibrator. Fortunately Monday night was warm and the ship stayed high.

Early Tuesday morning the America sighted the steamer Trent from Bermuda, and tried to speak her with wireless. She had none, but she did respond to the Morse code on the "blinkers," and came promptly alongside. Wellman valved his hydrogen and came as low as he dared. The crew and the mascot cat got into the lifeboat. Four or five feet above the water they let go the release hooks. The lifeboat struck the Atlantic with a smack, and the America, thus abandoned, soared away. For a Parthian shot the equilibrator struck the side of the lifeboat a tremendous blow like that of a crocodile's tail. This stove in one side, and the Trent, seeing the emergency, bore down at full speed and stove in the other. But Wellman and his crew, and the gray cat, got safely on board the Trent and had the satisfaction of realizing that, save for their guide rope, the America had been a huge success — and that their experiment, unsuccessfully concluded after one thousand miles of devious flight, had clearly pointed the way to the successful achievements of a later day.

Until 1907 the Wright brothers had maintained undisputed sway in American aviation. They *were* American aviation. There was no one else. Yet all this time a young man

by the name of Glenn Hammond Curtiss had been steadily at work in his motorcycle factory, and by 1907 (when he was not yet thirty) he had built three hundred and fifty motors, of which fifty were for aerial experiment work.

Riding his motorcycle one day in 1907 at Ormond Beach, Florida, he made the fastest speed that a human being had ever made up to that time — a mile in 46⅖ seconds. This achievement caught the eye of Alexander Graham Bell, the inventor of the telephone, who in those days was experimenting with tetrahedral kites — that is, kites made up of cells, like a honeycomb. As a result, they collaborated in the Aerial Experiment Association, for which a laboratory was established at Curtiss's home in Hammondsport, New York. Here he turned out the Red Wing and the White Wing and the June Bug. With the latter he won the *Scientific American* trophy on July 4, 1908, for the first entirely public airplane flight made in the United States which should last for a distance of one mile. The June Bug made it in one minute and 42⅖ seconds.

Curtiss later turned out to be one of those rare airmen who find themselves equally at home with lighter- and heavier-than-air craft. It was he who designed the motor for the first lighter-than-air machine purchased by the United States army — a dirigible built by Captain Thomas S. Baldwin and successfully tested at Fort Myer in August 1908.

Meanwhile in Europe, and in France particularly, aeronautical history was speeding rapidly ahead. On October 18, 1909, Count de Lambert astonished the world by flying from Juvisy Field around the Eiffel Tower, fifteen miles away, and back again. This exploit, Orville Wright insisted, was the finest heavier-than-air flight that had yet been made.

Wilbur Wright himself had performed an almost equally creditable feat in New York City that same month. He flew from Governor's Island up the Hudson to Grant's Tomb, a distance of ten miles, circled over the great fleet of warships assembled to take part in the Hudson–Fulton celebration, and returned safely.

It was not until January 10 to 20, 1910, that the first important American aviation meet was held. This came at Los Angeles, California, and there Louis Paulhan won the altitude prize with a height of 4000 feet. There also Glenn Curtiss made a new world's record for speed with a passenger by reaching 55 miles per hour. Curtiss distinguished himself further in the same year. On May 29, he flew the 150-mile distance down the Hudson River from Albany to New York in 2 hours, 51 minutes. Thereby he won the $10,000 prize offered by the *New York Herald*. This achievement produced a flock of other offers. Within a week of the Curtiss flight, the *New York Times* offered $25,000 for the first flight between New York and Chicago over a 960-mile course in less than seven days. The *Chicago Evening Post* duplicated the offer. Then the *New York World* and the St. Louis *Post-Dispatch* offered $30,000 for a flight over the 1000-mile distance from New York to St. Louis. Finally the Washington Chamber of Commerce and the Aero Club of Washington offered $25,000 for a 225-mile race between Washington and New York. Less spectacular but far more sensible was the offer by Edwin Gould of $15,000 to the successful designer and demonstrator who would add to the safety of air travel with a machine of two engines and two propellers.

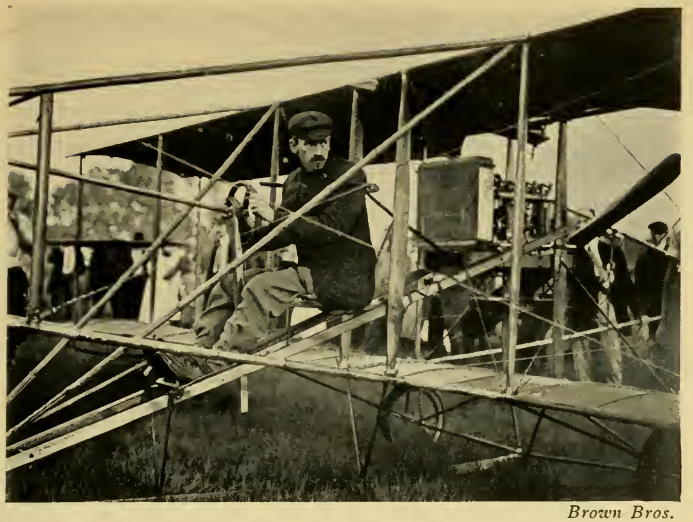
Still another American cross-country record fell in this same year. Under the auspices of the *New York Times* and the

Philadelphia *Public Ledger,* Charles K. Hamilton made the first flight between New York and Philadelphia and return in twenty-four hours. Here was a quiet commentary on the state of aeronautics in the year 1910. The round trip which these newspapers considered a feat in twenty-four hours could be made by the Pennsylvania or the Reading railroads in four. At 7.43 in the morning of June 13, Hamilton, a pupil of Curtiss, set out, following a special train, one car-roof of which was painted white. He made the 86-mile outward journey in 2 hours, 45 minutes. After a stop of two hours in Philadelphia — a long time for a New Yorker — he started home. Defective spark plugs brought him down at South Amboy, New Jersey, and there, spark plugs being scarcer than they are to-day, he was delayed for five hours. Notwithstanding, he landed again in New York at 6.40 in the evening, having accomplished his voyage in less than half the time stipulated by the insufficiently rigorous donors.

In the fall of the year came the great Belmont Park Aerial Tournament. Here was an aviation fair at last to rank with the Reims meet. The most sensational of all events was a race from Belmont Park to the Statue of Liberty on Bedloe's Island and back — 34 miles in all. To the man who finished first Thomas Fortune Ryan, financier, offered $10,000. Three men made the circuit around the goddess and got home again. Two of them were famous aeronauts — Grahame-White of England and De Lesseps of France. But the winner was a newcomer to fame — John B. Moisant of the United States, who made the journey at an average speed of only a fraction less than a mile a minute. He made the 34 miles in 34 minutes, 38.84 seconds. Grahame-White was less than three quarters of a minute behind him. Earlier, Grahame-

White had fared better in winning the speed contest for the Gordon Bennett trophy by making an average speed of 61 miles per hour. A year previous, at the Reims meet, Glenn Curtiss had won this trophy by flying 47 miles per hour. The intervening year had shown a great improvement in aircraft — an improvement that was evidenced in still another way when Ralph Johnstone set a new world's altitude record by climbing 9714 feet.

This same year saw still another achievement. At the time, it seemed little but a spectacular and foolhardy stunt; in reality it was one of the most significant accomplishments in naval history. Lieutenant Eugene Ely flew his Curtiss plane (carrying wheels only) off the deck of the U. S. S. Birmingham in Hampton Roads. Then, two months later, he reversed his experiment and landed on the deck of the U. S. S. Pennsylvania in San Francisco Bay. The Navy Department stirred slightly and wondered if it might not be well to equip new battleships each with an airplane of its own. Certainly these feats of Ely pointed the way in 1910–11 to the eventual addition to all important navies of the airplane carriers that we now know so well. Not long thereafter Captain W. Irving Chambers, U. S. N., developed the original catapult, operated by compressed air, to be used in launching planes from ships. It was first used successfully on November 12, 1912. Even the army became definitely a partisan of aviation, and Congress appropriated $125,000 to equip the Signal Corps with planes. Nineteen hundred and ten saw also the longest over-water flight yet to be made — that of McCurdy from Key West, Florida, to Cuba, ninety-six miles; and by Glenn Curtiss the first successful American take-off and landing on water. It witnessed also the first wireless connection between



Brown Bros.

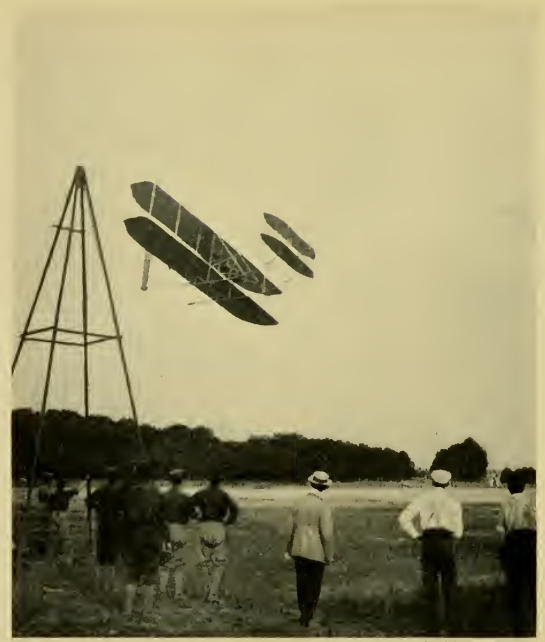
GLENN CURTISS

Another of America's Aviation Pioneers Seated at the Controls of One of His Early Planes (*Page 229*)

Brown Bros.

STOP FOR REPAIRS

Glenn Curtiss Pauses for Adjustments at Tarrytown, N. Y., in the Course of the Flight from Albany to New York City Which Won Him the Scientific American Trophy (*Page 230*)



Underwood & Underwood

IN THE AIR

One of the Later Flights of the Wright Brothers in 1910. The Launching Tower is at the Left (*Page 230*)

Brown Bros.

WITH ROYALTY

At Pau, France, Wilbur and Orville Wright Stand Covered in the Presence of His Britannic Majesty King Edward VII

plane and ground, and saw, through the courage of Chavez, the Alps first crossed by plane.

The meet at Squantum, Massachusetts, provided Ralph Johnstone with an opportunity for setting two new records. One he achieved by landing 5 feet 4 inches from a set flag and thus making a new standard for accuracy in alighting. And for duration and distance he set marks of 100 miles and of 3 hours, 5 minutes. Grahame-White twice distinguished himself by flying from Squantum to Boston Light and return — thus duplicating a feat which had earlier won him the $10,000 prize of the *Boston Globe*.

And 1911 should be particularly famous on one account now almost forgotten. For that was the year in which Calbraith P. Rodgers made the first transcontinental journey by airplane. In that year, cross-continent flight was not economical of time. It took Rodgers 50 days to make his 4017-mile journey; by train he could have done it in one tenth the time. His journey began at New York and was completed at Los Angeles on November 5, 1911. His total flying time was 82 hours and his average speed 40 miles per hour. He made many separate take-offs and landings, but he did set up a world's long-distance record for air journey which was to endure for a long time.

It was the year of great prizes. Vedrines won $20,000 for being the winner of the 776-mile Paris–Madrid race in May, his total time being 12 hours, 18 minutes.

A number of less spectacular races and records rounded out the year. Prier made a nonstop flight between London and Paris. But fatalities were mounting now as well as achievements. Three men were killed in the very first day of the International Circuit Races between Paris and London, be-

ginning on June 19. The course to be followed was Paris, Liége, Spa, Utrecht, Brussels, Roubaix, Calais, Brighton, London, Calais, Amiens, Paris. Here was a grueling 950 miles to be done in nine stages. Of the thirty-nine starters only sixteen finished the first leg of the race and only nine completed the course. The winner was Lieutenant Conneau, who went sometimes by the name of Beaumont.

Conneau had won an earlier race from Paris to Turin. Original plans called for the prolongation of the race to Rome, but only four of the original twenty-nine entrants could get as far, even, as Turin. Thereupon the race was declared ended, for the hazards of trying to jump the Apennines were considered too great. Conneau was also the first to bound the British Isles by air. He won his $50,000 race from among thirty entrants in July 1911.

America, too, was having its innings. Lincoln Beachey flew over Niagara Falls and under the Suspension Bridge fifty years after Blondin had crossed the Niagara River on a tight rope. Harry W. Atwood flew in hops from St. Louis to New York and thereby won $10,000. Airmen slowly began to try their wings with greater daring.

During the early months of 1912, Melville Vaniman, who had been a member of Walter Wellman's crew on the America when he had two years before attempted a transatlantic crossing, had been grooming a craft of his own for the flight. He put months of work into the building of the great dirigible Akron — only to have it destroyed with its crew of five men over Absecon Inlet, Atlantic City, on July 2, 1912, during a trial trip. For some cause which was never determined, the Akron burst suddenly into flame, carrying her entire crew to death.

But no accidents, however gruesome, could extinguish in men's minds the romantic idea of flying the Atlantic. In 1913, Garros flew across the Mediterranean Sea, a distance of 500 miles. Two Frenchmen, Vedrines and Bonnier, flew the 3500 miles from Paris to Cairo. And these two achievements caused much talk of the possibility of a transatlantic flight in the newspapers and magazines of the year. Then, in 1914, two great enticements were dangled before the eyes of the aviation world. Lord Northcliffe, proprietor of the London *Times,* offered $50,000 for the first successful completion of a nonstop transatlantic flight. And the directors of the Panama-Pacific Exposition went even further — they offered $150,000 for the quickest round-the-world flight in less than ninety days. The route was to be San Francisco, New York, Labrador, Greenland, Iceland, Scotland, Russia, Siberia, Japan, Alaska, and San Francisco again — a total distance of about 21,000 miles.

These two offers set the aeronautical world by its ears. Obviously, thought everyone, the world now stands on the verge of accomplishments on a scale that had never before been dreamed of, and all this only eleven years after the first heavier-than-air flight was ever made. Rodman Wanamaker announced himself as a contestant for the Northcliffe prize, and Glenn Curtiss was commissioned to build a twin-motored (later changed to tri-motored) seaplane, to be called the America, in which the attempt would be made. The flight, said Mr. Wanamaker, would be made in July.

But two days before that month began, a Serbian youth whose name is dimly remembered as Gavrilo Princip leveled a revolver at the Archduke Francis Ferdinand of Austria and his wife as they drove through the streets of Sarajevo. In due

course of time, ultimatums followed, and the mobilization of the Russian, French, Austro-Hungarian, and German armies came swiftly. Before the month was over, Europe was in a flame of war.

XXIV

AVIATION AND THE WAR

The war which started only eleven years after the Wright brothers had first demonstrated that man could fly produced a swift forced growth in aviation. At least the progress in aviation which came about as a result of the war was available, when the war was over, for peace-time purposes — something unhappily not true of any other instrument of war.

For, up to 1914, the war-time possibilities of the airplane were much more evident to men than were the peace-time. Sir Hiram Maxim, Alberto Santos-Dumont, Count Zeppelin — these men saw little use for flying except as a military weapon. The Hague Peace Conference in 1899 had solemnly voted to prohibit aircraft from discharging projectiles or explosives. Reconnaissance and other strictly noncombatant uses were to be permitted. This was quite typical of the statecraft of the earlier century — man had not learned how to fly, therefore it was quite appropriate to prohibit him from flying. The Great Powers cheerfully put their signatures to this agreement without even the usual necessity of crossing their fingers when they signed. But by 1907 heavier-than-air flight was four years old and Santos-Dumont and Count Ferdinand von Zeppelin were having spectacular success with their dirigibles. Now that it actually seemed possible that aircraft might be of some use as an offensive instrument of

war, the Great Powers were no longer so eager to limit the uses of this new weapon. The new clauses that were written about aircraft immediately took on a noticeable vagueness.

Between 1910 and 1914 much was said about the possibilities of aircraft in warfare. In these days men anticipated that aircraft would be used for (*a*) reconnaissance, (*b*) spotting artillery fire, (*c*) photography and mapping, (*d*) bombing, (*e*) firing on enemy troops with machine guns, (*f*) attack on enemy aircraft, (*g*) transport of staff officers.

It was seldom found necessary to be so expeditious with staff officers. Otherwise, this forecast of the uses of the airplane was deadly accurate. English writers, into the bargain, added many words about the menace of the Zeppelin to England. Long before the war, it was obvious that the airplane would be used to the very limit of its capabilities, no matter how much talk there was at The Hague or elsewhere.

When the war began, Germany had six hundred airplanes. They were mainly two-seaters, and — trust Germany — almost all on a standardized design. France had an almost equal number; but they were not standardized, and many repairs and replacements were necessary before they could be welded into any sort of fighting unit. Along with the first hundred thousand men that Lord Kitchener whipped overnight into an army for England, he sent just eighty-two planes. Belgium had twenty. All were slow, clumsy machines with little climbing power.

To France and then to England, at the outset of the war, young Anthony H. G. Fokker, aeronautical genius of Holland, offered his services as designer and builder of combat aircraft. Both these nations, which seemed to have had only a hazy notion of the scale upon which the war was to be

fought, refused his offer, because they said he wanted too much money. He then turned to Germany and was promptly snapped up. He proved to be the aeronautical genius of the war. The myriad planes he turned out were pitted against those of Sopwith, De Haviland, Farman, against the Bristol fighter, Nieuport Scout, Handley-Page, and the Spad, yet not until 1916 did the Allies begin to achieve supremacy over Germany in the air. Fokker had cost the Allies far more as an enemy than he would ever have cost them as a friend.

One by one, the uses to which the anxious forecasters of the war had assigned the airplane came to be fact. Reconnaissance and scouting planes (and fighting ones also) were able to work as far as one hundred miles behind the enemy lines. Combat planes revived the individual fighting of cavalier days, and extended the area of battle to a distance of three or four miles above the field. The airplane not only justified its existence as a scout to locate artillery fire; it spelled the entire doom of the cavalry unit for scouting purposes. The Germans used seaplanes to patrol the Baltic and the coast of Holland and Belgium. The English used many squadrons to protect from air raids the fleet at Scapa Flow, in the Orkneys; also that at Rosyth, in the Firth of Forth. And, as the wily Santos-Dumont had years before predicted, aircraft, both lighter and heavier than air, proved to be of the greatest use in spotting submarines. At a considerable altitude, it could still discover the presence of a submarine some distance below the surface. A wireless message from the aeronaut would soon bring a destroyer to the vicinity. Submarines in consequence came to be fitted with skyward-pointing attachments for their periscopes. It was a seaplane which first sighted German ships before the battle of Jutland and told Admiral

Beatty that there was action ahead. Seaplanes directed battleship fire at the Dardanelles and made possible direct hits from fifteen-inch guns at a range of twelve thousand yards.

Aerial photography swiftly became a fine art, although for its most perfect flowering it had to wait until the United States entered the war and a young American, now world-famous, Sherman Fairchild, devised an aerial camera of almost supernatural accuracy. Between November 1917 and the Armistice, the British alone took two hundred and sixty-five thousand photographs. Even in early days photographs showed much that the eye could not see; indicated the beginnings of new pathways not observable to the eye on the ground, but from the photograph obviously being used for the movement of troops, and the like. Camouflage became an immediate and vital necessity, and even camouflage often proved inadequate once airplanes were equipped with stereoscopic cameras which would show whether a clump of trees was really a clump of trees or something painted upon a flat piece of canvas.

Bombing began in amateurish fashion and was all too soon subjected to many cruel refinements. The first record of it came in September 1914, when Lieutenant Immelman bombed Paris and dropped a note on a sandbag which read: "People of Paris! Surrender! The Germans are at your gates! To-morrow you will be ours." The first bombing planes were like any other planes — except that the pilot carried up with him a small box of bombs which he flung overboard when he thought he saw a likely target. This crude state of affairs did not last long. Huge planes of special design were shortly in the air carrying bomb racks below their wings. A movement of the bomber's hand and an elaborate

releasing gear would send projectiles, most of them weighing 110 pounds, hurtling to earth with every possible allowance made for wind, horizontal speed and elevation.

At first, combat pilots going into the air for hand-to-hand battle with the enemy carried only a revolver or a rifle. Soon after the first battle of the Marne, Germany began mounting machine guns on the fuselages of planes and sent aviators aloft with a new and powerful aerial weapon. The whirling propeller, however, presented a serious obstacle. One type of machine gun could be fired only straight ahead; yet a machine-gun bullet might instantly shatter the propeller. The French ace Garros (famous as the peace-time aviator who flew the Mediterranean), so the rumor went, had invented a device to eliminate this difficulty. The Germans succeeded in forcing him down uninjured behind their lines. Thereupon Fokker, who had never before seen a machine gun, succeeded within several days not only in duplicating Garros's invention, but in producing a fool-proof synchronizing gear which made it possible to fire five hundred machine-gun shots per minute directly through propeller blades that were flashing perhaps four thousand times a minute past the muzzle of the gun.

The record of valor in the air was amazing, and many of the feats of heroism almost incredible. There was, for example, Captain René Fonck, who is supposed to have brought down 126 enemy machines and who had 75 victories officially to his credit — which means that three or more eyewitnesses observed the battle and the outcome.

Worthy in every respect to be ranked with René Fonck was Major William A. Bishop, ace of aces in the British Army and a member of the Canadian Expeditionary Force. To him went credit for 72 victories and for the incredible feat

of sending down four German planes out of seven which he met one day while flying alone. Second to Fonck among the French was Georges Guynemer. He belonged to the famous Cigognes Escadrille, and the testimony of three or more eyewitnesses credited him with 53 victories before September 11, 1917, when he vanished.

Among the Germans, Baron von Richthofen and his flying circus stood out. He was credited with 80 official victories.

A pilot became an ace when he had official credit for the defeat of five or more enemy planes. Germany had 88 aces; England had 85; the United States had 63. France was able to amass only 49; Italy 14; and Russia 3.

Aerial combat swiftly made the manœuvres of peace time seem slow and clumsy. The stunt flying which had begun when Pégoud had made the first voluntary loop-the-loop and discovered that it was quite as possible to fly upside down as right side up became an everyday part of a pilot's training in war. The tail slide, the Immelman turn, and the spinning nose dive that had once been fatal to any pilot who accidentally fell into it, all became matters of routine. Under the harsh necessities of war, amazing strides were made in the design of planes for the increase of stability. And where earlier the most incessant watchfulness and consummate skill were necessary to keep a plane in proper flight, more than one combat ship during the later years of the war glided safely to earth with a dead pilot at the controls.

Other features of design improved with equal swiftness. In 1914 the weight of engines per horsepower lay between 3.5 and 4 pounds. By 1918 this figure had been reduced to 2.5 pounds. Before the war, maximum wing loading was only 4 pounds per square foot; by 1914 this was 6 pounds; at the

close of the war, in 1918, progress in the design of wing sections and more scientific modes of construction had increased the figure to 10 pounds. To-day it is 14.

Speeds likewise showed marked increase. At the beginning of the war a speedy plane could do 126 miles per hour; when the Armistice was signed, the standard was 160. In 1914 planes weighed not more than 2000 pounds; by 1918 a giant bomber, the Porte Baby, weighing fifteen tons, was ready to zoom through the skies. Her five engines could carry twenty-four men and two tons of useful load. Constructors made progress also on planes of metal construction, designed to increase structural strength and to reduce the terrible hazard of fire from incendiary bullets.

When the United States flung its energies into the war in 1917, it was forced to start the aviation race from scratch. In 1908, you will remember, the United States Army had purchased its first plane, and in the same year Congress had appropriated $125,000 to develop the Aviation Section of the Signal Corps. By the time war was declared, nine years later, this section was composed of 65 officers and 1100 men. It had 200 training planes, not one of which was fit for battle service. Moreover, no planes were being built by the United States. America, home of the Wright brothers, had permitted its aeronautical heritage to slip completely from its grasp.

As a first step toward building an air fleet, an aeronautical mission was sent to Europe, in June 1917, in charge of Major Raynal C. Bolling. In it were flying officers from both army and navy, industrial experts, skilled mechanics, and factory experts. The total personnel was over one hundred men. To this mission was entrusted the vital task of studying European methods of plane manufacture.

The automotive engineers of the nation then pooled their resources for the development of the famous Liberty motor. It was developed during 1917 and produced in quantity during 1918. By October of that year the ten-thousandth motor had been produced and production was up to 3878 motors per month — for use not only on American but on Allied planes. It was a twelve-cylinder motor which developed 400 horsepower at 1275 revolutions per minute.

In 1917, Congress appropriated $675,000,000 for the development of a battle fleet in the air.

On May 29, 1918, Major General Mason M. Patrick was made chief of the newly created United States Air Service. The need for new planes was desperate. The Germans only two days later launched their third attack at the Marne.

Less than four months afterward, on September 12, 1918, when there came the famous American offensive on the Saint-Mihiel salient, the United States had twenty squadrons at the front — and Colonel William Mitchell found himself the commander of the largest air force that had ever been assembled for battle. There were 701 pursuit planes, 366 observation planes, 323 day bombers, 91 night bombers — a total of 1481 aircraft. For during the year 1918 the United States had built 20,000 planes. Money and energy had at last triumphed over bad preparation.

In the comparatively brief time at their disposal, American pilots made a record for valor in the air worthy to rank with their allies. The American ace of aces, Major Edward V. Rickenbacker, was credited with 25 official victories. The names of Raoul Lufbery and Frank Luke, Jr., rank high. In all, the personnel of the United States Air Service received 611 decorations —from England and from France as well as

by enactment of the United States Congress. United States pilots achieved 781 officially confirmed victories over enemy planes and 73 over enemy balloons — meanwhile losing only 289 planes, and 49 balloons of their own. The tiny force of 65 officers and 1100 men had grown to 7611 officers and over 70,000 enlisted men in France and England. And the 200 miserable training planes with which the United States went into the war had flowered into this: pursuit planes, 3337 for service, 90 for schools; observation planes, 3421 for service, 664 for schools; day bombers, 421 for service, 85 for schools; night reconnaissance, 31 for service. Of training planes there were 2285. There were 30 experimental planes and 108 miscellaneous — to a grand total of 10,472, delivered to the American Expeditionary Force between December 12, 1917, and November 16, 1918.

Three days after the Armistice was signed in 1918, the Germans completed the Zeppelin LZ-72, which had been built for the express purpose of bombing New York City. She was 770 feet long, 95 feet high, and 88 feet wide. Her hydrogen capacity was 2,470,000 cubic feet. She had a total lifting power of 85 $\frac{3}{4}$ tons, six Maybach engines totalling 1440 horsepower, and capable of developing 62 miles per hour. She had a gasoline capacity of 11,000 gallons and was designed for a nonstop voyage of 9500 miles. Had she ever started, she would have carried four and a half tons of bombs. She was, however, immediately surrendered to France and became the Dixmude, which perished with all on board in a storm over the Mediterranean in 1923. On December 21, she was seen over Biskra, North Africa. On December 27, fishermen six miles off the coast of Sicily found the body of Lieutenant de Grenedan, her commander, in their nets.

Zeppelins did not make a particularly illustrious record during the war. England had anticipated air raids; after October 1, 1914, her cities were dimmed at night to make spotting difficult. The first Zeppelin raid occurred on January 19, 1915; but, despite a total of twenty-five bombs dropped on Norfolk, Snettisham, King's Lynn, and Yarmouth, the results, from a military point of view, were unsatisfactory. All in all, only fifty-three bombing raids were carried out by means of Zeppelins. Heavier-than-air bombers made sixty-three raids — and whereas the Zeppelin operated always at night, the majority of heavier-than-air bombers operated by day. London alone was bombed twelve times by airship and nineteen times by plane.

It is, however, an error to think that Germany did all the bombing. Germany began it; yet during the entire duration of the war Germany dropped only 275 tons of bombs on non-combatant England, whereas England alone, in 1918 alone, dropped more than 5000 tons of bombs on non-combatant Germany.

In 1917, a year and a half before the final collapse of the German cause, Count Zeppelin died at the age of seventy-nine — just too soon to witness one of his ships make the longest cross-country nonstop flight that had ever been achieved by aircraft of any kind until 1929. On November 12, 1917, a Zeppelin left Jamboli, Bulgaria, with twenty tons of medical supplies for the forces under Von Lettow fighting the British in what was then German East Africa. She crossed the Mediterranean and followed the course of the Nile. At Victoria Nyanza Falls, she received a wireless that Von Lettow had surrendered. Thereupon she turned back and arrived at Jamboli four days after her start, after having

covered 5500 miles at an average speed of 57 miles per hour.

Before the end of the war, planes were carried on all first-line English battleships, and naval airplane carriers had been constructed from converted transatlantic liners and cruisers. Before these came, ships of the line carried their own planes, mounted on top of gun turrets and launched by catapult. Yet, notwithstanding the aviation activities of all navies involved, there is no record that any naval vessel was sunk or seriously damaged by bombing from aircraft at any time during the World War.

And when the shadow of the war did finally roll away, believers in the future of aviation could find comfort in the fact that at least five years of accomplishment had been packed into every one of struggle — so far, at least, as the design, construction, and operation of heavier-than-air craft were concerned.

XXV

THE BANNER OF EXPLORATION

When the war ended, the victor nations found themselves with thousands of flying ships — and thousands of pilots found themselves with nothing to do. It was quite inevitable that things should once again begin to happen swiftly in the brave story of pioneering in the air. Yet it is amazing that things should have begun to happen so fast — that the world of aviation and the men who made it up could recuperate so swiftly from the strain of war and could so quickly readjust their thoughts from extermination to exploration.

Naturally, the first nation to pick up the banner of aerial exploration and adventure was the one which had suffered least — the United States. And it was, accordingly, the fliers of the United States Navy to whom first came the renown of a great post-war achievement.

The year 1919 was, in many ways, one of the most spectacular years in the history of aviation. The London *Daily Mail,* in the very month of the Armistice, renewed its offer of £10,000, originally made in 1913, to the crew of the first airplane which should make a nonstop flight across the Atlantic in less than seventy-two hours. It might be from east to west or west to east, and the ground points might be anywhere in the British Isles and anywhere in Newfoundland, Canada, or the United States. Aviators, mostly British, rose

promptly to this alluring bait. And so the world was once again treated to the thrills of an aviation race. The team of Harry Hawker and Lieutenant Commander Kenneth MacKenzie-Grieve, R.N., the team of Captain John Alcock and Lieutenant Arthur Whitton Brown, the team of Raynham and Morgan, and the team of Major Gran, Major Brackley, and Rear Admiral Kerr, all began preparations for the first airplane flight across the Atlantic Ocean.

Meanwhile the United States Navy began on transatlantic preparations of a different sort. The Navy did not undertake its flight in the spirit of adventure; it was a cold, well-calculated, scientific attempt to test the endurance and practicability of aircraft in long-distance flying. Accordingly the route was laid out in stages — the first from Trepassey Bay, in Newfoundland, to the Azores; the second from the Azores to Lisbon, Portugal; the third from Lisbon to Plymouth, England. Over this route, twenty-one United States Navy destroyers were to be stationed in a string from Newfoundland to the Azores at intervals of sixty miles; thereafter, British warships would stretch to Lisbon, in constant patrol of the route of the fliers for protection in case of mishap.

To make the attempt, the Navy supplied the three biplane Curtiss flying boats NC-1, NC-3, and NC-4. The three were identical sister ships. The hull of each was divided into six water-tight compartments. The first, in the bow, housed the navigator. The second and third housed the two pilots. In the fourth and fifth were fuel and oil tanks. In the sixth was a wireless operator. The total crew was composed of six men. The ships weighed twelve and a half tons and had 400-horsepower Liberty motors.

Carefully and methodically, the Navy fliers put their ships

through all necessary trials. Hawker and MacKenzie-Grieve, Raynham and Morgan, all of whom had thought they would be ready long before the Navy planes appeared, watched with mounting concern. Finally, in spite of fire and other mishaps, on May 16, 1919, at 10.03 in the evening (a night start was planned so that the landing would occur in daylight), the three Navy ships took off from Trepassey Bay, Newfoundland. The NC-4, in command of Lieutenant Commander Albert C. Read, early took the lead which she was destined to hold throughout. She sped over the icebergs with which the north Atlantic was strewn, her way lighted ahead by star shells and searchlights of the destroyers, and at 11.27 the next morning she sighted Flores Island — the most westerly of that curious collection of islands known as the Azores. At 1.23 in the afternoon of May 17, Commander Read brought his ship down at Horta, having covered 1380 miles in 15 hours and 17 minutes, with a consequent average speed of 74.8 knots.

The tale of the other two ships is not so happy, although no fatalities resulted. The NC-1, under command of Lieutenant Commander P. N. L. Bellinger, lost her bearings in the fog and was forced down in a rough sea two hundred miles west of the Azores. The Greek steamship Ionia (Norfolk to Gibraltar) promptly picked up her crew and tried to tow her to safety, but the towline parted. The plane was picked up on May 17, at ten in the morning, by the destroyer Harding.

As for the NC-3, she had the most colorful if not the most successful adventure. She, too, lost her bearings in fog and came down. The ocean was rough, and her skipper, Commander J. H. Towers, could sight no ship in any direction. There was no alternative — the NC-3 must ride out the gale as best she might. Her seaworthiness stood the test, although

one engine was torn loose and her hull sprung leaks. When the winds abated, she was able to sail with the wind, although she could not take off. In this fashion she covered the 205 miles that remained to reach Ponta Delgada, where she arrived on May 19, bravely afloat but badly damaged.

Only the NC-4 was in condition to carry on. After flying 9 hours and 25 minutes she covered the remaining 800 miles to Lisbon and arrived there on May 27. On May 30 she left Lisbon for Plymouth, but due to engine trouble came down at Ferrol, Spain. After a stop of a few hours she took off again for England, where at last Commander Read brought his ship safely into Plymouth. The Atlantic had at last been crossed through the air, and the dream of the aeronaut Charles Green translated into a reality by the skillful and courageous Navy fliers.

But the public still yearned for a flight with a dash more of adventure to it — and many an aviator still yearned for the £10,000 prize of the London *Daily Mail,* for which, of course, the Navy fliers were not competing. On May 18, two days after the NC ships had flown out into the darkness, Hawker and MacKenzie-Grieve went up on what the people of Mount Pearl Farm (the best field they could find near St. John's, Newfoundland) thought was one more of an apparently interminable number of trial flights. Hitherto something had always been wrong. The weather was bad; winds were unfavorable; the engine needed tuning.

In England, Hawker had made a highly successful test flight of 1800 miles with his 5000-pound 350-horsepower Sopwith biplane, which he called the Atlantic. Then, knowing that Charles Green and John Wise had been quite right about the west-to-east air currents which swept the Atlantic,

he and MacKenzie-Grieve had come to Newfoundland. Thereafter there had been a long wait.

At 5.51 P.M. Greenwich time, on May 18, Hawker and MacKenzie-Grieve flew down the hill of Mount Pearl Farm, 350 gallons of gas in their tanks. The heavy plane lifted slowly, all but struck a fence, and then gained altitude. Watchers glanced at her idly; they had seen her before. But as they watched, the 450-pound landing carriage suddenly detached itself from the bottom of the plane and fell to the ground. Then it was that the people of St. John's knew that this was no trial flight for Hawker and his companion — that once and for all they were off on the great and glamorous adventure of making the Atlantic in a single hop. The dropping of the undercarriage had told them that, for the airplane was so constructed that the carriage could be released at will, and was to be dropped on the final take-off in one last desperate attempt to save resistance. How Hawker and MacKenzie-Grieve would land when the time came no one knew — least of all they. They would face that problem when they came to it.

From above St. John's they saw the rival Martinsyde plane still in its airdrome. On the ground, Raynham and Morgan began desperate preparations to get off. An hour later they started, only to break an axle on the runway and spill ignominiously before their nonstop Atlantic flight had carried them more than half a mile. Hawker and MacKenzie-Grieve, meanwhile, had vanished into fog.

And they vanished, so it seemed, for good. The suspense of the next day changed to doubt. When five days had gone by, the doubt changed to despair. Hawker and MacKenzie-

Grieve had not been heard from. The King sent a telegram of condolence to Mrs. Hawker for her husband's loss.

But on May 26, as the tiny steamer Mary (Duhn, master) of Copenhagen ploughed past the most northerly point of the Hebrides, Lloyd's signal station on the Butt of Lewis received a signal which it could scarcely credit. The Mary carried no wireless. Her master asked therefore that the station wireless that Hawker and MacKenzie-Grieve were safe — that he had rescued them at 8 A.M. on May 19, 1050 miles out of Newfoundland.

The newspapers blazed with the excitement of the rescue. Gradually the story of the voyage came out. Fog, darkness, rain, and north wind had come down upon the fliers almost at once. Notwithstanding, they made good time, their engine turning over sturdily with no hint of trouble. Soon, however, its temperature mounted dangerously. The water in the radiator began boiling away, forming steam, which turned into ice when it struck the chill blast of the air. Hawker throttled down his engine and coasted. Examination showed that solder in the radiator had come loose, and had plugged the water circulation system. The Atlantic slid forward, slowly losing altitude. One thousand feet above water Hawker snapped on the ignition of his engine once again. The motor would not start.

Not until the plane was on the verge of plunging through the crests of the waves did the motor cut in again and the fliers become able to make altitude. When daylight came and they could take their bearings, they discovered that they had gone 950 miles. But the radiator was still boiling, and it was obvious that Hawker and MacKenzie-Grieve would never reach the coast of Ireland. Through light fog and rain they searched for

a vessel. Finally, a faint smudge showed them one. They bore down on it with all their speed, circled three times around it, and landed on the water just ahead. That was the story that the world learned on May 26. Later it learned that the airplane itself had been picked up by an American ship, S. S. Lake Charlotteville, and forwarded to England, its tanks still half full of gasoline. An insignificant bit of solder stood between Hawker and the $50,000 of the *Daily Mail*. But he was given $5000 consolation prize by the *Daily Mail* and both fliers were decorated by King George.

For some days Harry Hawker was a hero. The magnificent courage of his flight, the apparent tragedy of his end, the incredible romance of his rescue — all these elements combined to make him hailed the world over. Florenz Ziegfield, who always knows a sure-fire hit when he sees it, offered the flier a theatrical contract at a handsome figure.

But Hawker's tact was not up to his navigation. In one of the first public statements with which he was credited, he took occasion to suggest that the flight of the NC planes was nothing to be particularly proud of. " If you put a ship every fifty miles of the way across the ocean," he is reported to have said, " it shows you have no faith in your engine." And with that, Harry Hawker went into eclipse. Even Florenz Ziegfield withdrew his offer. And yet, beyond question, Harry Hawker told the truth. He phrased it bluntly and undiplomatically, but the words he spoke were no less sensible on that account.

Captain John Alcock, D.S.O., and Lieutenant Arthur Whitton Brown (of American parentage) had been English aviators during the war. They came out of their experience

alive, largely because they had been captured early and had spent up to November 1918 in enemy prison camps. With a remodeled Vickers-Vimy standard bomber they arrived at St. John's, Newfoundland, at midnight on Saturday, May 24, 1919, to try their luck. The Vickers-Vimy was a biplane, with a capacity for 865 gallons of gas and two 350-horsepower Rolls-Royce motors. Alcock and Brown were speedy at their work. They made their first trial flight on June 9. On June 10, Rear Admiral Kerr, in his Handley-Page, responded by making a trial trip of his own — much to the discomfiture of Alcock and Brown, who had thought themselves well ahead of their other competitors. The roar of someone else's motors overhead gave them their first intimation of the closeness of the race. On June 12 they made their second trial flight and announced themselves ready on June 13. Kerr, however, to the infinite glee of Alcock and Brown, needed wireless alterations and new radiators.

The fliers of the Vimy bomber struck while the iron was hot. On June 14, 1919, at 4.28 P.M. Greenwich time, the crowds on their improvised air field, clutching tight at their hats in the blast of the Vimy's propellers, watched mechanics pull the chucks from under the wheels and saw the ship begin to lumber slowly up the field. Alcock and Brown, each with a black cat for mascot, had taken off. They had taken off on what should be known everywhere to-day as an epoch-making flight in the history of aviation. Unhappily the immortality of their achievement has somehow been obscured in America.

A steady northeast wind sent the Vimy bomber bowling along at a speed of 100 miles per hour. Brown, the navigator, was anxious to take a sight. Alcock, the pilot, took the plane

up to 12,000 feet. At this altitude they rose above the fog to see the moon and stars. Calculations showed that they were too far north. The wind was drifting them, but how much? "We 'd better hit it downstairs, Jack," Brown is reported to have said, "and see if we can get the amount of drift from a whitecap."

So they hit it downstairs. Fog was there again, and before either flier realized how much altitude they had lost the Vimy bomber all but dove into the waves. Alcock flattened her out barely in time, and shortly afterward Brown managed to check the drift by a sextant sight on the crest of a wave. Up they shot again to a height of 11,500 feet, where a helping wind drove them along at a speed of 125 miles per hour. The moon shone, but not for long. Then the rain began. "It 's hard to tell, Art," said Alcock, "whether to put up an umbrella or get into a bathing suit."

At last, 350 feet above the water, Alcock found a hole in the fog. The rain continued. Through the weak daylight that had now followed night the two fliers saw a ship — but by now they were impressed by the dangers of coming too close to the surface of the Atlantic. They decided to brave the fog, and rose 12,000 feet to steer by the compass through an impenetrable gray mist that was everywhere.

Alcock thought his instruments uncertain but he was more than anxious not to clip the tops from any more waves. To correct for any loss in altitude, he nosed the Vimy bomber up. At least, he thought he did. It was at this point that the black cat, Twinkletoe, demonstrated her true worth as a mascot. A desperate scratching at the seat indicated that she and her companion were having some curious difficulty in clinging to it. In the fog, Alcock had turned his plane upside

Brown Bros.

THE TRIUMPHANT CRASH

The Vickers-Vimy of the Immortal Alcock and Brown — and How It Landed in Ireland (*Page 256*)

Wide World

CHARLES AUGUSTUS LINDBERGH

Aviation's Most Famous Figure

Wide World

RICHARD EVELYN BYRD, U. S. N. RET.

Explorer of the Poles by Air

down. He shifted his controls until expressions of comfort and contentment once more wreathed the faces of his cats. Then, he felt, uprightness had been reëstablished.

Soon the fog cleared. Shortly thereafter, Alcock and Brown sighted two small islands and knew that their voyage was close to its end. They saw the wireless station at Clifden, Ireland, and beyond it, at 8.40 A.M. on June 15, what seemed a lovely, level green field. They swooped down, hoping for a safe, smooth, comfortable landing. The wheels struck, sank deep; the plane ploughed its nose downward, up-ended completely; and Alcock and Brown and the two mascot cats clambered out unhurt to find themselves mired in a rich sticky bog. *That* had been their landing field of pleasant green.

But what did it matter? Four hundred and twenty-seven years after Columbus, the Atlantic had been spanned without once touching earth or water. Alcock and Brown most properly became Sir John Alcock and Sir A. Whitton Brown, and the Vickers-Vimy bomber with the Rolls-Royce engines was dug out of the Irish mud to take its historic place in the Science Museum, South Kensington, London.

Neither Raynham and Morgan in their Martinsyde nor Rear Admiral Kerr and his party in the Handley-Page ever took off. The attempts of the Rear Admiral faded into complete obscurity. Raynham and Morgan came to a more manly if less comfortable end. Their Martinsyde crashed on the final take-off and their attempt was abandoned. Not for eight years was the record set up by the gallant Alcock and Brown to be challenged by another attempt to cross the Atlantic without recourse to water.

XXVI

OCEAN AND JUNGLE

The year 1919 was not half over when the world rang with the news of the triumphant flight of Alcock and Brown. Their flight, Commander Read's, and Harry Hawker's furnished enough aviation history for any one year. But 1919 was a great year for aviation, and was to see two more great achievements before it closed. In one of these two, lighter-than-air craft — which since the Reims meet had been seriously overshadowed by exploits in aviation — was destined temporarily to turn the tables; to set up, in fact, one record which airplanes have never yet been able to equal.

It was the English dirigible R-34 in command of Major G. H. Scott, A.F.C., which wrote history for dirigibles. In 1919 she was one of the two largest ships in the world. The other was her sister, the R-33. For months before the Armistice, England had been secretly at work building these ships in Scotland, with the idea that they would voyage to Germany and visit reprisals upon Berlin in exchange for what the Zeppelins had done to London. The first trial flights of the R-34 were held the very week in which Germany signed the Armistice. By way of further test she reconnoitred over Germany before the Treaty of Versailles was signed.

But her military value had vanished, and her proponents

were quick to suggest her value as a means of experiment for long-distance, nonstop, lighter-than-air flight. With the two big sister ships they proposed a dual trip, one ship to take a northerly route, the other a southerly. Both would stay as short a time as possible in the United States and reverse their routes on the way home. Construction on the R-33 lagged and it was determined that the R-34 should go alone — but not until after defeated Germany had signed the treaty of peace.

The R-34 made test flights over the North Sea while the world waited for this historic event. Herr Mueller and Dr. Johannes Bell wrote their signatures on the treaty on June 28; four days later, at 1.30 in the morning, the R-34 put off to sea. She was 643 feet long; her gas capacity was 2,000,000 cubic feet; her diameter was 80 feet. She was powered by five 270-horsepower Sunbeam motors, carried 5670 gallons of gasoline, and had a theoretical radius of action of 5000 miles. She carried ten officers and a crew of seventeen. She was also the first ship to carry an aerial stowaway — since found essential for the completion of almost all transatlantic flights. Lieutenant Commander Zachary Lansdowne, U. S. N., was likewise on board as an observer, by courtesy of the Royal Air Force, for the United States was thinking of building a dirigible of its own.

No sooner had the R-34 set out from the southern bank of the Firth of Forth and mounted 100 feet than she found herself lost in fog. Vaguely, her officers could see the lights of Rosyth. More altitude was necessary; no one on board had any wish to bump into any of the 3000-foot hills that cover northern Scotland. Yet 3000 feet was a difficult altitude to attain with the weighty load the ship carried, although

14,000 feet was no trick for her when she was lighter. She felt her way cautiously over Scotland, struck bumpy air over the mouth of the Clyde, came finally to the north coast of Ireland, and started off across the Atlantic. It was about this time that Sergeant Watson found the stowaway, William Ballantyne, hid in the rigging between gas cells Nos. 6 and 7. Ballantyne was a rigger, who had formerly been employed on the ship, but who had been laid off to lighten the load. He spent the balance of his voyage helping the cook.

The first day passed uneventfully. The off watches of the crew slept in hammocks slung from the triangular keel of the ship. The wireless room reported uninterrupted communication with the East Fortune wireless station. A graphophone on board helped vanquish monotony. At 3.45 in the afternoon tea was served. Then the R-34 went up to 2000 feet above the cloud line and sailed through burnished blue skies with a cotton ocean of cloud rolling underneath.

Bad weather did not mar the voyage until the ship was off Newfoundland. She sighted icebergs drifting down from the north and rose speedily, lest the chill current from them should contract her hydrogen and force her down. At 12.50 P.M. on July 4 her crew first sighted land — in the shape of a few rocky islands that make up Trinity Bay, Newfoundland. It had been fifty-nine hours since they had left the coast of Ireland behind them. Hastily they flung over a mail sack attached to a parachute — English postage stamps would have done these envelopes no good on American soil.

They were ploughing through ragged fog now and watching a thunderstorm crawl toward them from the coast. This they escaped by putting on all engines and rapidly detouring southeast.

But the gasoline supply was a worry now. Far more than the allotted quantity was gone when, at 4 A.M. on July 6, they sighted Chatham, Massachusetts. Every mile was a battle; by no possible chance could the ship's tanks hold more than five hours' additional supply of fuel. Head winds would spell the ruin of their plans, with success almost at hand.

Luck decided it. The R-34 made the last lap of her journey in four hours and three quarters. While the ship hovered 2000 feet over Roosevelt Field at Mineola, Long Island, Major J. Pritchard jumped over the side with a parachute to direct the landing party. The cheer that went up from six hundred workman when he struck the ground ascended to warm the hearts of the voyagers. The R-34 had covered 3200 miles in 108 hours and 12 minutes and had just one half hour's supply of gasoline left in her tanks. A member of the triumphant welcoming party was Commander Albert C. Read of the NC-4 — the first man in history to have flown the Atlantic. Bands played "God Save the King," but the tumultuousness of the welcome did not swerve the Federal Government of the United States from its duty. An immigration inspector, a health officer, and a customs officer promptly went through their routine.

For four days the R-34 was the show piece of Long Island. Swiftly, damage caused by the wind on July 7 was repaired, and she was once again made ready for flight. Sharp at midnight on July 10 she set off again for England, carrying twenty-five pounds of mail in which was included a letter from President Woodrow Wilson to George V, R. & I. Searchlights from the field projected a flying shadow one hundred times her size on rolling banks of clouds as she disappeared. She

made nine hundred miles in her first twenty-four hours of flying and landed in the early morning of July 13 at Pulham, near Norfolk, after only seventy-five hours in the air. If the Atlantic did not feel subjugated then, it should have.

But there was still aeronautical history to be made in 1919. Toward its close it witnessed a flight the magnitude of which showed the strides which aviation had made in the course of one decade. In 1909, Louis Blériot had pushed the airplane to its ultimate limit by flying a little over 20 miles. In 1919, a crew of four men under the command of Captain Ross Smith of the Royal Flying Corps traveled 11,060 miles in a two-engine Vickers-Vimy converted bomber.

They did it in answer to the prize offer of £10,000 made by the Australian Commonwealth for the first flight from London to Australia to be made by Australians in an all-British-built plane, the flight to be completed in less than 720 hours — that is, thirty days.

On November 12, 1919, just a year and a day after the signing of the Armistice, at eight o'clock in the morning, the Vimy plane, closely similar to that which had carried Alcock and Brown across the Atlantic, took off from Hounslow Airdrome, piloted by Captain Ross Smith, M.C., D.F.C., A.F.C. It carried five hundred gallons of gas, forty gallons of oil, and food for a week. A schedule of stops for refueling and provisioning had been carefully made. And these were to be her romantic ports of call: London, Lyons, Pisa, Rome, Taranto (it was here, four centuries before Christ, that Archytas was reputed to have flown his wooden pigeon), Crete, Cairo, Damascus, Ramadi, Basra, Bandar Abbas, Karachi, Delhi, Allahabad, Calcutta, Chittagong, Rangoon, Bangkok,

Singora, Singapore, Kalidjati, Surabaya, Baima, Attambola, and finally Port Darwin, Australia.

To add an extra measure of excitement to this daring voyage, Captain Smith and his crew of three had a race with a French pilot named Poulet, who, although barred by nationality from the prize competition, was anxious to be the first man to fly from Europe to Australia. Poulet had a start of several thousand miles. When Smith made Cairo, Poulet was already in India. The Vimy bomber caught him finally in Burma and passed and left him at Rangoon. Captain Smith and his crew landed at Port Darwin on December 10, 1919, after twenty-seven days and twenty hours of elapsed time, and won their prize by a margin of a little over two days.

It had been a trip packed with adventure. Even the Atlantic Ocean was more populous than many of the desert lands over which Captain Smith flew; a crash which did not kill the fliers instantly could have had as its only alternative death by the slow torture of thirst and starvation. The escapes were many and narrow. Once, near Calcutta, they were all but wrecked when a hawk flew into one propeller. Nothing of the hawk could be found thereafter, but the Vimy bomber was itself after minor repairs.

Captain Smith's descent at Surabaya in Java very nearly proved the end of his flight. Australia was only twelve hundred miles farther away, but his plane seemed hopelessly stuck in the soft mud of the landing field and her roaring engines would not pull her off. Captain Smith's resourcefulness came quickly to his aid. With bamboo mats commandeered from houses and wherever else he could lay his hands on them, he made a 900-foot pathway in the mud. On the first attempt the draft from the propellers lifted the

mats up in the rear of the plane and fouled the tail. The Vimy bomber promptly ran off the track and lodged once again in the mud. But on the second try, with the mats painstakingly pegged down, the Vimy bomber ran straight and Captain Smith and his crew soared off to the final glory they had earned.

Swiftly, aviation reached out for new worlds to conquer. The lure of danger still hung over the dark continent of Africa, and in 1920 still another Vickers-Vimy bomber set off on a voyage of discovery. The purpose of the expedition was given as "a serious attempt to show whether Africa could be traversed easily and safely from end to end by proper aircraft in ordinary conditions and a pioneer effort in exploration from the air." Its scientific leader was Dr. P. Chalmers-Mitchell, Secretary of the Zoölogical Society. The ship's pilots were Captains S. Cockerell and F. C. Broome.

They, and a crew of two, left Cairo, Egypt, on February 6, 1920, bound for Cape Town, on a route of 5206 miles that was to lead them over strange, wild country, choked with jungles and thronged with savages — territory on which no human eye had ever looked down before.

But this expedition was not destined for all the good luck which attended Captain Ross Smith. The first forced landing took place just outside of Mongalla when empty gas tanks cut the engines out. That night the expedition slept in the plane to be out of the way of crocodiles. Next day they induced a native to set out on foot to Mongalla for gasoline. He returned with it — and in ten minutes the Vimy bomber flew a distance that it had taken the native six hours of hard travel on foot to cover.

The Cape Town voyage came to an end at Tabora, on February 27, 1920, after the Vimy bomber had made 2700 miles — more than half her flight. The intense heat of the tropics was more than the engines could stand. Radiator troubles piled up, and the end came with sudden and pathetic ignominiousness when one landing wheel was torn off in a forced landing in which the plane bumped into an African ant hill.

A second attempt to bridge the gap from Cairo to Cape Town was made by Lieutenant Colonel Pierre van Ryneveld (a South African Dutchman) and Flight Lieutenant Brand. They started on February 10 in the darkness of early morning, while Dr. Chalmers-Mitchell's expedition was still struggling. Radiator troubles due to African heat beset them even earlier than the other expedition, and on a forced landing they wrecked their machine, although no one was hurt. With the same engines, but a new plane, they tried again on February 22 and made 3880 miles in thirteen days before they crashed at Bulawayo in Rhodesia. Here they sent for a De Haviland plane from Cape Town and thus completed the voyage.

The really successful aerial crossing of Africa did not come until 1926, when the Imperial Airways, Ltd., commissioned Alan J. Cobham to survey the aerial route from Cairo to Cape Town. Cobham chose a De Haviland plane with a 385-horsepower Jaguar motor of radial air-cooled type, to avoid the radiator troubles of the past. He took off from England on November 16, 1925, with a mechanic and a photographer whose apparatus included a motion-picture camera. From Cairo he jogged by easy stages along his 8500-mile journey. At times he encountered a temperature near the ground of 160

degrees in the direct rays of the sun. In spite of the desperate heat, he made his destination on February 17, 1926, after having spent only ninety-four hours in the air.

Then, just to show how easy it was with a proper type of engine, he turned around and flew back again. The experiences of the return trip were in many ways even more extreme. At one time he was treated to the sight of a procession of twenty lions (all British) threading their way through the jungles. And he had the almost incredible experience of encountering a violent sandstorm at an altitude of 12,000 feet. For all this, he flew back from Cape Town to Cairo in nine and a half days and reached London less than six days later. He became thereafter Sir Alan J. Cobham, K.C.B.E.

Two years later Bert Hinkler, in an Avro biplane, made the first solo flight between London and Port Darwin, Australia. There he landed on February 22, 1928, after a 12,000-mile journey which took fifteen and one-half days. Then, just to show how easy flying had become, Lady Mary Bailey, in a D. H. Moth plane equipped with a Cirrus engine, landed at Cape Town on April 30 after a solo flight from London. Then she soloed back again, retracing the 8000 miles to Croydon Field, from which she had taken off on March 9.

Aviation had completed the conquest of another continent.

XXVII

SHRINKING NORTH AMERICA

EUROPE was laced with airlines. Africa, usually thought to be the most inaccessible of continents, had been flown from end to end. Airplanes had linked the British Isles to their farthest colonial possessions. In 1922 one continent, however, remained unconquered. That was the continent of North America. For all the impetus of the war, the United States was once again lagging in aviation. Commercial travel by plane was common abroad. A regular service across the English Channel, begun in August 1919, swiftly carried passengers from London to Paris. There was scarcely such a thing as any regular passenger service in the United States.

Of course, air-mail service had come into existence. In 1919 the Post Office Department had resumed the experiments made and discontinued between New York and Washington by the Army during the war. First from Cleveland to Chicago, then from Chicago to New York, still later from Chicago to Omaha, and after that from Omaha to San Francisco — gradually, air-mail fliers completed the linkage of the coasts by air. But there was not yet a through service because in the United States there was no such thing as night flying, although Germany had experimented with it even before the war. Obviously, then, a nonstop span of the United States

offered a challenge to aviation. Lieutenants Oakley G. Kelly and John A. Macready decided that something could be done about this.

Macready, in 1922, was the distinguished holder of the world's altitude record, with a height of 34,509 feet. To him Kelly suggested the idea of a cross-country flight, and the two immediately formed a team. The machine they chose was the T-2, a Fokker monoplane with a 420-horse-power Liberty motor and a capacity for 557 gallons of gasoline inside the wings and 180 gallons more in the fuselage.

Both aviators immediately bent themselves to their plans. Their original idea was to cross the continent from east to west so that the high mountains of the western country would be surmounted when most of the gasoline load was gone and a high altitude easier to achieve. "No," said the United States Weather Bureau. "Go west to east; that is the way of the prevailing winds."

So Kelly and Macready took the Weather Bureau's advice, though to do so they must fly through the passes of the mountains and not over the peaks. Everyone with whom they discussed their contemplated flight assured them that it was beyond man's power of endurance. Doctors pursed their lips, shook their heads, and soberly advised against it.

On October 4, 1922, the weather report was favorable, and in the early morning the fliers took off from Rockwell Field in San Diego. They flipped a coin to see which man should have first trick at piloting, and Kelly won the toss. He found it hard to get his plane off the ground; in fact, so great was the load that he taxied for nearly a mile before she lifted. He circled twice to gain an altitude of two hundred and fifty feet and then struck east. At Temecula Pass, fifty miles from

San Diego, Kelly had reached an altitude of 1700 feet. In spite of the Weather Bureau, the fog had become heavy, and the fliers were none too sure that they might not have the disconcerting experience of bumping into a mountain side. Somehow, they got safely through.

But by the time they reached San Jacinto the fog was all but impenetrable. Visibility was no more than fifty feet. The chances of finding the proper pass were practically nothing; sufficient altitude to clear the peaks could not be attained. Wisely, Kelly and Macready turned back to Rockwell Field. They reached there, but they did not descend. Instead, they dropped a note to their commanding officer, explaining that since they could not get over the mountains in the fog the next best thing to do was to break the world's endurance record. They proposed to do this.

And do it they did. Throughout the long, cold night, in the light of a full moon, they circled endlessly about. All next day they kept it up, to come down at last after 35 hours and 18 minutes — only to find that red tape had deprived them of the official record. They had not continuously been observed or timed.

On November 4, at dawn, after a busy night of preparations and with less than three hours' sleep, Macready and Kelly started once again on their cross-country flight. They flew out to sea to gain altitude and then turned back. This time Temecula Pass and San Jacinto had no terrors for them, but the air was rough and the T-2 all but scraped the tops of the Rockies at Tucson. And at Tecolote, New Mexico, where the highest land had to be jumped, an air pocket nearly bumped them to the earth. Finally, with the mountains behind them, they sped over Oklahoma and Kansas.

Night came on, and with it a violent thunderstorm. Macready and Kelly watched the lightning light up the flat landscape for miles, and then ducked low to avoid the clouds. Actually, they were on the edge of a tornado, and only by great good fortune escaped it. Only by great good fortune also did they escape the chimney of a Kansas farmhouse; Macready insists that the undercarriage came within twelve inches of it.

Just before dawn, Macready and Kelly saw the lights of St. Louis and knew that they were halfway across. It had not been easy going. Only four hundred miles out of San Diego a water jacket around one cylinder had cracked. Now, a few miles beyond Terre Haute, a second one began squirting away the precious water that the engine would need to be able to complete the trip. Kelly ransacked the plane for anything liquid, and poured beef broth and coffee into the radiator. The ailing cylinder could not retain even this mild nourishment and Kelly and Macready grounded their plane on the Indianapolis Speedway, vowing that if they ever made another cross-country attempt it would be by covered wagon.

A little rest did much toward reviving them. They went on to McCook Field, Dayton, not only to make their plans for a third transcontinental attempt, but also with the idea of once again breaking the world's endurance record — this time officially. On April 16 and 17, 1923, with Orville Wright acting as official observer for the world-wide keeper of aeronautical records, the Féderation Aeronautique Internationale, Macready and Kelly succeeded in establishing the endurance time of 36 hours, 4 minutes, and 34 seconds. This record was made over the same territory where Orville Wright and his brother first made their halting power flights.

Encouraged by this success, Macready and Kelly resolved that they would not give up their transcontinental ventures. They would cross the continent in a nonstop flight or die in the attempt. They asked the Weather Bureau: "Does the wind *never* prevail from east to west?" The answer was yes — there was usually such a prevailing wind for a few days the last of April every year during the peculiar weather condition known as the "Hudson Bay High." So the fliers put a new engine into the T-2, flew to Mitchel Field, Long Island, received on May 1, 1923, assurances from the Weather Bureau that conditions were good, moved to Roosevelt Field, where more room was to be had, and tried to take off.

After two unsuccessful attempts the plane rose slowly into the air on May 2, 1923, at 12.36 P.M. It cleared the hangars, telegraph wires, and trees by scant feet. They crossed New Jersey without more than 400 feet altitude. Across Pennsylvania, guiding themselves by a maze of roads, they made their journey.

At dusk they were flying over Dayton, Ohio, well ahead of schedule. The moon was up, the skies were cloudy. By the time they were over St. Louis a rain had begun which, a little after midnight, ceased suddenly and brought the plane out once again into bright moonlight. Dawn, and they were over adobe huts in New Mexico.

Again the mountains interposed their bulk between the fliers and their goal. The T-2 would not mount the peaks west of St. Johns, Arizona. Swiftly, they looked for a pass. They found one, followed it in, and found themselves suddenly in a maze of canyons that all but swallowed them. They turned around just in time to avoid bumping the canyon's end wall.

They emerged unhurt, but with all familiar landmarks gone. How were they to get to Phœnix, the next familiar spot they hoped to pick up? The answer is, they never did. With success so close they abandoned their route and flew due west by compass. At Wickenburg, Arizona, they picked up the tracks of the Sante Fe Railroad and thereafter followed them through. The Colorado River, the Imperial Valley, one last mountain range — they left them all behind, and landed at San Diego, California, at 11.26 on the morning of May 3, 1923. They had made their nonstop flight across the continent and traveled 2516 miles in 26 hours and 50 minutes — averaging thus a shade less than 100 miles per hour for over a day of steady flying.

Among the floods of telegrams of congratulations they found this: "Congratulations on your wonderful flight, which beats my time made seventy-one years ago by oxcart. At two miles an hour, I was five months on the way. Happy to see in my ninety-third year so great a transformation in methods of travel. Ready to go with you next time. Ezra Meeker." And there was another telegram, too, this one from Colonel Frank R. Kenny, who had won a $5,000 bet on the flight and who insisted on turning over the entire sum to Macready and Kelly; for there was no London *Daily Mail* to spur them on — only the satisfaction of having written another great achievement into the history of aviation.

To-day the Fokker monoplane T-2 resides proudly in the Smithsonian Institution at Washington, D. C.

Before another year had passed, distance was annihilated again and the map of the United States shrunk to even more insignificant proportions. This time the hero was Lieuten-

ant Russell L. Maughan, U. S. A., who during the war had been credited with four victories over enemy planes and who had converted his war-time honors into peace-time achievements by winning, in October 1922, the Pulitzer Race Trophy with a speed of 206 miles per hour. Now he proposed an idea more spectacular than any that the world of aviation had heretofore seen. He would race the sun across the continent.

Long before daylight on July 10, 1923, barely two months after Kelly and Macready had jumped from ocean to ocean in one hop, a Curtiss pursuit plane stood tuned and ready at Mitchel Field, Long Island. Lieutenant Maughan stood beside it. The sun at that time of year was due to rise on New York at about 5.30 A.M. daylight saving time. The first faint glow of its coming showed at 4.56 daylight saving time, and Lieutenant Maughan gave his motor the gun and roared away, spouting sparks at the coral-colored horizon. His speed in a short time rose to 100 miles per hour and even that he found it necessary now and then to exceed.

He struck fog over Pennsylvania and flew in it unceasingly until it lifted at Akron, Ohio. At this point he had drifted one hundred miles off his course, and when he reached McCook Field at Dayton he was an hour and thirty-five minutes behind his schedule. Swiftly he repaired a damaged fin, took on gas and oil, and thundered away. At 160 miles per hour he flew across Indiana and Illinois, cornfields, woods, and villages blurring below him. His next scheduled stop was St. Joseph, Missouri, but fifteen miles to the east his engine spluttered and died, and he glided down to a pasture, amid a circle of dreaming cows. He had made 1330 miles in nine hours, but now, with a gas line clogged mysteriously

with dirt, his flight was ruined. He hastened once again back to New York and Mitchel Field.

On July 19 he made his second start. After only four hours' sleep he opened up his throttle at 5.08 A.M., taxied down the field, and vanished on the same course as before. Once again he struck fog in Pennsylvania. Notwithstanding, he reached McCook Field in Dayton at 8.35 A.M., clambered out, gulped a few mouthfuls of breakfast, clambered in, and sped away again. But he was almost two hours late and fogs had closed in once more.

He landed at St. Joseph at 11.45, fought off the cheering crowds, lay down on an army cot for a few moments' rest, and had a lunch of fried chicken, ice cream, and milk — scarcely a training-table diet. He was quite deaf. The ceaseless roar of the engine had made it practically impossible for him to hear a word that people said to him. The relaxation, the fried chicken, the ice cream, and the milk took only thirty-nine minutes. He was late again, and swiftly he opened his engine up until the Curtiss plane was logging 170 miles per hour. But the sun was speeding, too, and making no fuss about it.

Over Nebraska, stretching as flat as a lily pad before him, Maughan sniffed an unfamiliar odor. Rapidly it grew to be a poisonous stench that filled his nostrils, choked his lungs. An oil pipe had sprung a leak. A thin trickle of oil ran down over the hot engine and vaporized into a poisonous and stinking gas. Then the propeller blew the fumes full in his face.

For an hour and a half he stood it and then landed at 2.30 P.M. mountain time at Cheyenne, Wyoming. Forty-five minutes, and the leak was repaired. The blast of his pro-

peller rolled a small boy over backwards as he took into the air once more. Now, with the sun beginning to dip into his eyes, he drove his plane to its full capacity and reached a speed of 192 miles per hour; the sun also kept remorselessly but quietly at it. At 4.48 P.M. the citizens of Rock Springs, Wyoming, watched him pass — and ten minutes later they saw him circle back and land. Once again the oil tube had split. Temporary repairs were insufficient; not in less than three or four hours could a new one be installed. Lieutenant Maughan had to give up his second flight also.

His third attempt came almost a year after the first one. Now he had a new Curtiss pursuit plane, with tanks that would hold 170 gallons of gas and 13 gallons of water.

On the morning of June 23, 1924, the telltale on the flying field hung limp at its mast. In a dead calm, thirty seconds before 4 A.M. daylight saving time, Lieutenant Maughan took off for the third time, with a bright moon overhead, and a bare hint of sunrise in the east. At 7.05 Eastern standard time, flying this time in perfect weather, he reached Dayton. He left again at 8.16 and made the 570-mile hop to St. Joseph in 3 hours and 37 minutes. The clocks stood at 10.52 Central time when he paused for cold chicken, a glass of milk, and a rest. At 1.37 P.M. he landed at North Platte, Nebraska, with the weather still fine. By 2.17 mountain time he was in Cheyenne, with 1680 miles behind him. He glared triumphantly at the sun, which glared back. By 5.20 Pacific time he had reached Salduro, Utah. There for thirty-one minutes he rested from the terrific strain of his flight, and then took off on his last hop. He tore over Reno, Nevada, at 8.19, with an anxious eye on the slowly sinking sun.

The crowd gathered at Crissy Field in San Francisco

watched the sun, too. It sank lower and lower in the western sky and a fog rose over the Golden Gate. For more than three hours it had been pitch-dark at Mitchel Field, New York. "Go get him; bring him in," said Lieutenant Colonel William E. Gillmore to "Nonstop" Kelly.

The line of the horizon cut a segment from the sun. Then someone yelled, "He's coming!" Sirens screamed, and the wheels of Lieutenant Maughan's Curtiss plane touched the earth a bare moment before the last remnant of the sun's disc vanished. He had taken 17 hours and 52 minutes in the air to fly 2540 miles, and his average speed had been 150 miles per hour. To Mayor Rolph of San Francisco he handed a copy of the *New York Times* for the morning of that same day. Within the span of one sun, he had covered a distance that train and pony express took ten and a half days to make in 1860. The cheers that greeted him drowned the still faultless drumming of his engine.

XXVIII

DIRIGIBLES — TRIUMPH AND TRAGEDY

The Treaty of Versailles had provided, among other things, that a dirigible balloon, built after the fashion Count Ferdinand von Zeppelin had made popular in Germany for the last twenty-five years, be delivered to the United States in partial fulfillment of reparations. And so, in 1921, the Zeppelin Works at Friedrichshafen set about the building of their one hundred and twenty-sixth Zeppelin. She was finished in 1924 and christened the ZR-3. Her dimensions were 658 feet in length, not quite 91 feet in diameter, and a bit over 104 feet in height. She would carry a useful load of 60,000 pounds, and her five Maybach engines, each of 400 horsepower would drive her 63.5 miles per hour. Her cruising radius was to be 3500 miles. She had passenger quarters for thirty — with double-tier bunks arranged as in a Pullman car.

After one unsuccessful attempt, Dr. Hugo Eckener, president of the Zeppelin Company, got her off, and headed her south at 6.35 A.M. on October 12, 1924. She was to be flown across the Atlantic for delivery to the United States Navy. Soon she vanished into the inevitable fog that always seemed to surround long-distance fliers. She had a total complement of thirty-two, in whose eyes there stared great signs: "Nicht Rauchen" — which was to say "No Smoking." As a further deprivation, shaving was prohibited when water ran short.

At 60 miles per hour, the ZR-3 flew over the mouth of the Gironde River to the Bay of Biscay, sliding smoothly through the evening calm. A full moon lighted her course. At supper the crew sighted the Estacada lightship and said farewell to land. At one in the morning, Dr. Eckener manœuvred his giant craft over a steamship and, after an exchange of salutes, obtained his position. The ZR-3 was sixty miles off her course to the south. Over the Azores, next afternoon, she dropped a mail pouch by parachute. A rip in a gas cell, which might well have been serious, was found and repaired in time.

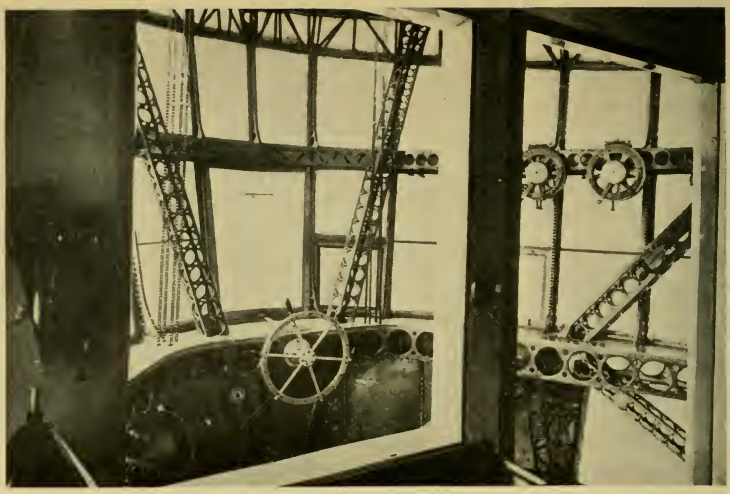
Just west of the Azores, wash water gave out altogether. Anyone who got dirty must stay that way, for water aboard the ZR-3 happened to be too precious for any use but drinking. No one minded. The voyage was progressing well; and although the ship struck fog off the Grand Banks it was not more than six hundred feet thick, and the ZR-3 cut her way up through and thereafter flew above it. At 5.25 in the evening of October 13, she sighted Newfoundland. Thirty minutes later she met and weathered a violent storm. By night she sailed softly over Boston in the clear moonlight, and by 7.30 in the morning of October 15 she floated in the sky over Manhattan Island, to the greeting of bells and whistles. Five times over the city Dr. Eckener circled his gleaming silver ship. For the second time, the Atlantic had been humbled by lighter-than-air craft.

At 9.52 in the morning he landed her safely at Lakehurst, New Jersey. She had made 5066 miles in 81 hours and 17 minutes and had thus achieved the record of making the longest over-water nonstop flight until then accomplished in the air. Only seven years after his death, the successors

Underwood & Underwood

GRAF ZEPPELIN

The Huge German Dirigible That Was the First to Circumnavigate the Globe



CONTROL ROOM

The "Bridge" of the Graf Zeppelin

International Newsreel

WIRELESS ROOM

Headquarters Through Which the Graf Zeppelin Maintains Touch with the Outside World

of Count Zeppelin made good his prophecy that some day his beloved airships would span the Atlantic. His ship safely delivered, Dr. Eckener and his crew sailed prosaically for home and the ZR-3 became the Los Angeles of the United States Navy.

Four years later, in 1928, Dr. Eckener repeated his triumph by making a round trip in the gigantic 770-foot Graf Zeppelin with a crew of forty and a passenger list of twenty. The westward trip was slow and marred by accident, but the eastward was more successful. A second trip almost ended in disaster, but a successful third immediately preceded the triumphant circumnavigation of the globe which Dr. Eckener achieved with her in four hops in August 1929.

Thus, in 1924, the Navy had two dirigibles. In the summer of 1919 Commander Jerome C. Hunsaker had been commissioned to design a rigid craft along novel plans. As a result, on May 4, 1923, the airship ZR-1 — named the Shenandoah, an Indian word meaning either "Daughter of the Stars" or "Place where the Waters are Muddy," depending on the authority one accepts — was launched. She had cost $2,000,000. She was 680 feet long, almost 79 feet in diameter, had six power gondolas, and was made of duralumin, an alloy developed by American and German chemists and containing aluminum, copper, manganese, and magnesium. She had a capacity for 2,115,500 cubic feet of gas. But the gas was not hydrogen. For the first time since the year 1783 this buoyant but dangerous gas was replaced by the less buoyant, more expensive, but entirely uninflammable gas, helium — in whose romantic history may be written the fact that it was discovered on the sun before it ever made its appearance on the earth. Helium is rare. In 1917 there were no more than one

hundred cubic feet of it in existence — and the cost per cubic foot was about $1700. The discovery of considerable quantities of it in Petrolia Pool, Petrolia, Texas, and elsewhere has by now reduced the cost to three cents per cubic foot, thanks to the researches of the United States Bureau of Mines and the anxiety of the United States Navy to bring this new gas out of the ground and into the air.

To tether such a sky monster, British aeronautical engineers had developed the mooring mast. This is a tower about 150 feet high with a swivel connection at the top. Into this connection an eye in the nose of the Shenandoah could be fitted. Any change in the direction of the wind would swivel the ship about like a weather vane and hold her head so that only her smallest cross section would offer any resistance to the air. Inside the mast is an elevator for embarking and pipe lines for oil, gasoline, and water — all of which nourishment the Shenandoah took through her nose.

In the fall of 1923 the Shenandoah made fifteen highly successful flights over cities in the East and the Middle West. But on the afternoon of January 16, 1924, a heavy southeast gale showed what it could do to this proud sky ship when it made up its mind. Captain Heinen, the German navigator who had been detailed to the United States to teach her naval officers the niceties of lighter-than-air navigation, was aboard when the gale struck, as was also a skeleton crew. One of the Shenandoah's six engines had been kept going to counteract the violence of the wind, but when one particularly violent squall struck, all but the nose of the craft was wrenched away from the mooring mast and Captain Heinen promptly found himself in command of a runaway dirigible — badly crippled and at the mercy of the storm.

He barked his orders. Promptly the Shenandoah dropped her water ballast, and mechanics started the other five engines. In the gale it was quite useless to attempt to keep a course — particularly because neither commander nor crew knew precisely where they were by the time the ship was brought under some semblance of control. Amateur radio fans promptly did their part to help Captain Heinen save the ship. All pleasure broadcasting was immediately stopped while observers to the south of New York reported to large broadcasting stations like WOR in Newark the apparent position and direction of the ship. By this means WOR found it possible to tell the Shenandoah where she was. And by 3.20 in the morning, while the remnants of her battered nose still hung from the mooring mast, Captain Heinen drove the ship through the fading storm to be housed safely again in the hangar at Lakehurst.

In October, now completely restored to health, the Shenandoah set out for the most ambitious tour ever yet undertaken in the air. In charge of Lieutenant Commander Zachary Lansdowne, she set off on a journey of 9000 miles which carried her to the West Coast and return and cast her long cigar-shaped shadow over seventeen states. On October 25 she was safe again at Lakehurst, with the distinction of having made the longest cruise in dirigible history and having been the first dirigible ever to fly over the waters of the Pacific Ocean or to meet the eyes of inhabitants of the American Northwest.

On September 2, 1925, the Shenandoah, once again in charge of Lieutenant Commander Lansdowne, cast off for a trip which was to take her to Pittsburgh, Columbus, Indianapolis, Kansas City, Des Moines, Milwaukee, Minneapolis, St. Paul,

and Detroit. Manned by her full crew of forty-one officers and men, she headed west.

Ohio in September is a bad-weather state. An interchange of correspondence seemed to show that Lieutenant Commander Lansdowne had never been too anxious to pilot his ship into that territory at that time of year. Orders, however, were orders, and on the morning of September 3 the Shenandoah sailed close to Marietta, Ohio. Shortly after 3 A.M. a line storm broke, and officers, huddled in the control car, debated in what course lay safety.

By 5.22 the air was a turmoil of currents. Within eight minutes' time the Shenandoah was driven to a height of 3150 feet. There she remained under control for six minutes. Then a terrific gust caught her and dropped her 3000 feet within three minutes. Almost as sharply she was driven again to a height of 3700 feet.

One of the greatest problems of the dirigible designer is to combine lightness with a strength sufficient to withstand the terrific bending moments which differences in air pressure on different sides of the envelope may cause. The Shenandoah was an eighth of a mile long, and slender. She was sturdily built, but in that twisting wind she was entirely helpless. Over a spot thirty-five miles north of Marietta she snapped into two pieces like a thin twig.

For less than a minute the control car remained attached to the forward section; then it broke loose and crashed to earth. At the same moment the large afterpiece of the ship broke in two, so that of the once proud silver ship there now remained but three broken floating fragments. The central section dropped swiftly. One third of a mile away the after section floated gently to the earth. Commander Lansdowne,

five other officers, and nine men had been killed when the control car crashed. Twenty-seven men, including Lieutenant Commander Charles E. Rosendahl, were left inside the forward section after the control car fell. Somehow they landed safely after a twelve-mile flight in the nose of the ship, which they had been able to operate as a free balloon.

The air had not yet been conquered. The accident to the Shenandoah was a tragic reminder of the fate that still waited in store for more brave men.

XXIX

ALWAYS WESTWARD

Even before the war, four nations — England, France, Italy, and the United States — had cherished the idea of flying around the world. In those days this idea had been a pleasant dream; now it was a possibility that skill, courage, and determination might well translate into fact. Ten years after the beginning of the war, the United States picked up the last broken thread of progress and began on the task of weaving it into the fabric of aviation's history.

There was more to flying around the world than picking courageous pilots and giving them sturdy planes. Advance agents had to be planted everywhere to make arrangements for refueling, as well as for repairs and installation of spare parts. And the consent of twenty-two different foreign governments had to be obtained before American planes could fly over as many different varieties of foreign soils.

From the Douglas Aircraft Company, Inc., in Santa Monica, the government purchased four biplanes with a wing spread of 50 feet, a capacity of 465 gallons of gas, and each powered by one twelve-cylinder 450-horsepower Liberty motor. The planes were not amphibians, but they were equipped with interchangeable undercarriages so that either wheels or pontoons might be used. Their weight was about four tons apiece.

Other countries had planned to fly toward the east, but the United States decided that its aviators should travel westward. Chances seemed better that the fliers would thus escape the Alaskan foggy season, the Chinese typhoons, the monsoons of India, and the rigors of an Arctic winter — all inconveniences to aviation.

In the entourage which was to undertake the most ambitious feat yet in the history of flight, there were four planes — the Boston, the New Orleans, the Chicago, and the Seattle. The Seattle was the flagship of the fleet; Major F. L. Martin, her pilot, was in charge of the entire party. The officers and crew of the other ships were these: the Chicago, Lieutenant Lowell H. Smith (pilot) and Lieutenant Leslie P. Arnold; the Boston, Lieutenant Leigh Wade (pilot) and Sergeant Henry H. Ogden; the New Orleans, Lieutenant Erik H. Nelson (pilot) and Second Lieutenant John Harding, Jr.

By March of 1924 the advance arrangements, which it had taken almost a year to make, were finally completed. On March 17 the four planes left Clover Field, Santa Monica, California, on a bee line for Seattle. Here, to the great discomfiture of all loyal Californians, many of whom insist to this day that the flight really did begin and end in Santa Monica, the great sky caravan was to begin its pilgrimage. And on April 6 the four ships took off upon the journey that was for the first time in history to girdle the earth by air. Behind the four departing planes there came an escort of ten more, bristling with moving-picture operators and newspaper men anxious to get their last glimpse of the flight that would never stop traveling westward.

The first hop was to Sitka, Alaska. Fog, the arch and omnipresent enemy, closed down on them at once. They made

their destination, only to lie storm-bound there for several trying days. With new supplies, they took off 625 miles for Seward, battling their way through one thick snowstorm after another. Then, beyond Seward, Major Martin in the Seattle was forced down by a fractured crankcase and rocked on the cold waters of the Pacific, 110 miles northeast of Chignik, for a day, until the United States destroyer Hull rescued him. By April 19 the Boston, the New Orleans, and the Chicago reached Dutch Harbor, there to wait for the Seattle. With a new engine brought by a coast-guard cutter from Dutch Harbor, Major Martin, anxious to rejoin his expedition, sought to reach Dutch Harbor in the combination of a heavy fog and a blinding snowstorm. He bumped, instead, into the side of a mountain many miles from the nearest outpost of civilization. For two days he and his companion, Sergeant Harvey, hugged close to their wrecked plane — held prisoner by the storm. On the third day the fog was still thick, but food was getting low. They tried again to escape toward the south and nearly walked off a 1500-foot cliff. Now the fog lifted and the sun came. Harvey went snowblind; Martin soon did likewise. Desperately they floundered on through the frozen stillness, camping where they could. Finally, seven days after their crash, an uninhabited cabin stocked with food and a rifle saved their lives. They were able, at last, to set out for Port Moller, twenty-five miles distant by their map. Here they arrived safely on May 10. Meanwhile headquarters in Washington had ordered the Boston, the New Orleans, and the Chicago to carry on, with Lieutenant Lowell H. Smith in command.

On May 3, therefore, the diminished caravan pushed on, this time for Atka, an island four hundred miles west of

Dutch Harbor. They followed the curve of the Aleutian Islands across the Bering Sea and, with the suddenness which is always surprising to people who do not realize that Nome is not more than two hundred miles from the nearest point on the coast of Siberia, they came under the kind auspices of Soviet Russia — to be exact, at Komansdorski Island. Here political differences suddenly thrust themselves forward; Soviet officials requested them to leave at once. Discussion was quite unavailing, as the Russians seemed to feel that the continent of Asia would somehow suffer a violent wrench if these young American aviators were permitted to set foot on Soviet soil. Lieutenant Smith and his party were forced to take their ships outside the three-mile limit.

The next hop was to Kashiwabara Bay, an indentation in the coast of Japan. The fliers made this stop with one almost involuntary record in their possession: for the first time in history a hop from land to land had been made across a stretch of the Pacific Ocean. From Kashiwabara they flew next to Tokyo, arriving there on May 24, when mechanics replaced the engines in all planes. Thus equipped, they sailed off for Shanghai and reached it on June 4. South to Hongkong their journey took them now and still farther to Bangkok, Rangoon, and Calcutta, wheels now serving them where pontoons had before.

Then, on the sun-baked plain of Allahabad, India, a newspaper man suddenly crawled out of the baggage compartment of the Boston and confronted Lieutenant Wade and Sergeant Ogden. With a pencil, a pad of paper, and a toothbrush, he had stowed away at Calcutta. His hitherto unwitting charioteers promptly set him to work to earn his passage by handling gasoline and oil drums. They came to

like him, and after some debate kept him as cargo and carried him two thousand miles to Europe.

Slowly the planes left the east behind. Aleppo followed Bagdad; Constantinople followed Aleppo; Asia Minor verged into the Balkans; from Bucharest the planes made Vienna; from Vienna, Paris; and from Paris the great Croydon airport in England.

Then the planes were fitted with pontoons again for the last quarter of their grueling journey. Off they sailed for the Orkney Islands.

Fog delayed them there. They champed impatiently, and as soon as the weather seemed to clear they started on the difficult jump to Iceland. Fog closed in again. The New Orleans pressed on, but the Boston and the Chicago turned back. With small incident the New Orleans made her goal, but when the Boston and the Chicago tried again, on August 3, tragedy stalked close to the expedition. Near the Faroe Islands, which had been a landing place for Norsemen on the way to Iceland a thousand years before, the Boston was forced down to the water by engine trouble springing from an oil pump gone suddenly bad. The New Orleans watched her stricken sister, broadcast a wireless call for aid and, being able to do nothing more, hastened on. The Boston threw out an anchor and waited.

The waves were rough. The Boston was far out of the usual steamship lanes. If the fog lowered any farther, the chance that either Wade or Ogden would ever be found was small indeed. One ship emerged out of a smudge of smoke and passed them by unseeing, despite the frantic signals and flares the aviators sent out. For half an hour they watched her bitterly, while she dwindled into the distance. The driz-

zling rain and the fog spelled the end of the world for Ogden and for Wade. Then suddenly they started. There was more smoke on the horizon. This time an English trawler answered the frantic signals and passed them a line.

Once made fast, the trawler thought to tow the Boston into port. The plan failed. With the Boston all but yanked to pieces, the trawler stood by waiting for another ship. Shortly, in answer to distress signals, the United States destroyer Billingsby and the cruiser Richmond foamed up. This latter ship completed the wreck of the Boston which the trawler had begun. On an attempt to hoist the Boston on to the Richmond's decks, the tackle broke — and now of the four planes which had taken off from Seattle five months before only two were left.

Meanwhile the Chicago had joined the New Orleans in Iceland and both, after coming dangerously near to ramming an iceberg in the fog, reached Greenland safely together. Here they were refreshed again with new engines and with these reached Labrador on August 31, 1924.

At Pictou, Nova Scotia, Lieutenant Wade and Sergeant Ogden joined them in their new plane Boston II, furnished them by the War Department to finish the voyage. The remainder of the trip around the world was a triumphal journey. Boston, New York, Washington, Dayton, Chicago, Dallas, El Paso, and Los Angeles met them. Then on to San Francisco, where the hysterical audience insisted that the flight by rights had ended; at last to Seattle, where at 1.28 on the afternoon of September 28, 1924, the three stout ships, New Orleans, Boston II, and Chicago touched again the same ground that two of them had left 175 calendar days before.

There were Magellans for the air now. They had girdled the globe in 15 days, 11 hours, and 7 minutes of flying time. They had traversed a course of 27,553 miles — 2651 miles more than the circumference of the earth at its equator. Four hundred and two years before — on September 6, 1522 — the Spanish ship Victoria, the only successful one of Magellan's fleet of five, had landed again at San Lucar in Spain after almost three years spent in girdling the globe for the first time by water.

There was glory and fame in this achievement for the six airmen — and they got their full and rightful share. But here was a challenge for engineers: the Chicago had needed six different engines to make the distance; the New Orleans had needed five. Many and many a 1915 flivver has done 26,345 miles on only one engine — and then perhaps tacked another 10,000 miles on top of that. Why was it that engineering skill had not yet been able to design for aviation a motor as satisfactory for its purposes as that the automotive engineers had designed for vehicles which stuck to the ground? Aviation experts settled down to the problem.

XXX

THE RACE FOR THE POLE

It was Henry Hudson who first tried to cross the polar sea to China. For his persistence his crew set him adrift in an open boat to die of cold and starvation, in 1611, among the icebergs of the bay that now bears his name.

After Admiral Peary first reached the North Pole in 1909, it became even more evident that Henry Hudson had a sound idea but had attempted to carry it out in an impossible way. It was not through the polar seas that man could reach China from Europe, but through the uninterrupted navigable ocean that reaches to every man's door: Cayley's ocean — the air. It may yet be the most important route from Europe to China.

Bit by bit, the airplane had conquered the continents and spanned the oceans. Eleven years after Kitty Hawk, aviators were planning busily to answer the last challenge to exploration — the poles. During the years that preceded 1925, men of six nations talked of using aircraft to leap at one jump to the top of the world. Only 413 miles, it is true, separated the pole from a land base at Admiral Peary's Camp Columbia. Yet it had taken him twenty-three years of planning and struggle to travel that distance and return. Now men talked of making the round trip in one day.

At 5 P.M. on May 23, 1925, two amphibian Dornier-Wal fly-

ing boats left King's Bay, Spitzbergen, for the first aerial voyage of Arctic exploration. In one was Roald Amundsen, the great Norwegian explorer, who by foot and dog sledge had reached the even more inaccessible South Pole in 1911. In the other was Lincoln Ellsworth, his American partner in exploration.

Amundsen had been one of the first explorers to realize the enormous value of the airplane in reaching inaccessible places. As early as 1914 he had made definite plans for a trip to the North Pole through the air. The war wrecked his plans — as it did with so many others.

Now, eleven years after, he was really on his way. Two other men sat with him in the plane N-25. Two more were with Ellsworth in the N-24. Almost immediately they ran into — can you guess it, now? — fog. They rose to an altitude of 3000 feet and the mists cleared. For eight hours they traveled at seventy-five miles per hour. But the strong northeast wind, they knew, was blowing them off their course, and they came down in a lead of open water to make observations. They were, they discovered to their joy, only 136 miles from the pole; in less than two hours, at their previous rate of speed, they could reach the top of the earth.

The wind freshened still further and the aviators had hard work to bring the planes, which had come down two miles apart, together again, since the ice was constantly shifting. The lead (which is to say the open water) started closing. Two men were disabled and both ships were all but wrecked. After a hard fight Amundsen and Ellsworth, with their crews, got the ships out of the water.

It was a problem now to know whether to attempt to dash home on foot with a canvas canoe for use in open water or to

attempt to get out with the N-25, the one plane that remained airworthy. They finally decided on the latter, but for twenty-five days they were held in the ice, trying constantly to find a suitable place for a take-off. The wind-torn ice in the Arctic, full of saw-tooth planes and angles, gave them no chance. After ten days' work they smoothed down an ice cake large enough for taxiing, and on June 15 they got free, all men traveling in the N-25. Eight hours of flying they accomplished. Then a forced landing with jammed ailerons brought them down at the edge of the ice pack, on Nord Kap, Nordostland, with only half an hour's supply of gas still left in the tanks. They taxied to land on the west side of Nord Kap, and a small sealing ship took them again to King's Bay. That was the end of the first Amundsen air expedition.

But the seed of the idea that the pole might be conquered through the air had now been sown, and within a year another American took it up. He was Donald B. MacMillan, sometime Professor of Anthropology at Bowdoin College. This sedentary occupation brought him his wages; he got his exercise periodically by joining polar expeditions. In 1908 he had been a member of Admiral Peary's party. Now, the National Geographic Society proposed to send him in search, by airplane, of the undiscovered land which Admiral Peary insisted must be somewhere near the pole, because of the bird migrations and the action of ocean currents. News of the Amundsen expedition speeded these plans.

At the same time a young officer in the Navy, Lieutenant Commander Richard E. Byrd, had very definite ambitions for a polar flight, and had asked the Navy Department for the necessary amphibian planes. MacMillan made the same re-

quest, and, since the available planes were limited, the two proposed expeditions were joined together as one.

MacMillan and Commander Byrd, with eight mechanics and pilots and three amphibian planes, took off from Etah, Greenland, in August 1925. Within a few hours MacMillan looked down upon many thousands of square miles of ice that he had laboriously crossed by dog sled with all manner of hardships in 1914–16 and in 1924.

By wind or ice, the amphibian planes came several times close to destruction. Each time, however, they escaped it, and the MacMillan-Byrd expedition made some effective explorations of Grinnell Land and the Fjords of Ellesmere Land. The ships also flew over the great Greenland Ice Cap — 700,000 square miles, an area almost eleven times larger than all New England, sheathed in solid ice over a mile thick. The expedition returned, with much good accomplished — and with the satisfaction of having taken a number of wondering Eskimos for an aerial joy ride. Yet MacMillan decided that planes were failures at Arctic exploration — that only lighter-than-air craft would do.

But Byrd was determined to go again; determined to be the first man in history to travel in the air over the very axis of the world. In his determination he was not alone, for Amundsen and Ellsworth were busy with new plans. In the dirigible Norge, — *i.e.,* Norway, for Amundsen's homeland, — which Colonel Umberto Nobile was building for them in Italy, they, too, proposed a polar flight. Again, as in 1909, when Blériot and Latham raced to be first to cross the Channel, the world was treated to the exciting spectacle of seeing two brave and determined men vie with each other for the honor of being first to open still one more path to aircraft.

Wide World

FARTHEST NORTH

The Byrd Expedition in Camp at Spitzbergen (*Page 295*)

Pacific & Atlantic

LUNDBORG'S DISASTER

What Happened to the Gallant Swedish Aviator who Helped in the Rescue of Nobile (*Page 300*)

Wright Aeronautical Corp.

WILKINS AND EIELSON

Before Their Gallant Take-Off in the North (*Page 298*)

Wright Aeronautical Corp.

THE SOUTHERN CROSS

The Scene at the Fiji Islands Stop of This Immortal Flight
(*Page 318*)

With Commander Byrd was Pilot Floyd Bennett. They had planned to start from King's Bay, Spitzbergen, on May 15, 1926, but plans went even more speedily than they had hoped, and, despite several crack-ups on attempts to take off, Byrd and Bennett were ready on May 8 to take off for the pole. The motors were warm; Bennett gave the Josephine Ford full throttle and the great ship started down the runway. She did gather momentum, but she did not gain altitude. The ship came to the end of the runway, skids still skimming on the ice, bounced over several hummocks of snow, and plunged straight into a snowdrift. Fortunately, however, the landing skids had not been broken, and by midnight the plane had been taxied back to her starting point, where the load was lightened to the last possible pound and a new start attempted. This time the Josephine Ford got off.

Bennett gave his engines all they would take. In response the Josephine Ford reached an altitude of 2000 feet and a speed of nearly 100 miles an hour. Swiftly they closed in upon their goal. Then Byrd, on the alert for every detail, saw the most chilling sight that an aviator flying far out of touch with civilization could ever see. The starboard motor had developed a bad oil leak. There were councils of despair, and Bennett urged that they land for repairs. Byrd, thinking of the difficulties of the take-off that morning and of Amundsen's experience, said No. Then the starboard motor settled matters by itself. As mysteriously as the oil leak had begun, it stopped again. The Josephine Ford was a bare hour from the position of the pole. She thundered on.

At 9.04 A.M. Greenwich time, on the morning of May 9, successive sights through the Bumstead sun compass indicated

that the Josephine Ford had reached the top of the world. They circled several times, snapped hasty photographs, paused long enough for a silent handshake, and turned home again. They reached it safely, but not without another incident that might have cost the lives of both courageous aviators. As the Josephine Ford banked sharply, the sextant toppled from the chart table and crashed to the floor. A vital means of checking position and thus charting the course vanished. Yet luck stayed with them. They were able to make their base again by means of the sun compass alone.

During supper that evening at King's Bay, when watches stood at 6 P.M. by Greenwich time, Amundsen and his party heard the roar of engines and looked out to see Byrd, Bennett, and the Josephine Ford about to land after their triumphant journey. It must have been a bitter blow to the veteran Norwegian explorer. He had been first to the South Pole in 1911. For thirty-three years he had been trying to reach the North Pole. Whatever his feelings may have been, he kept them hidden, congratulated the party with all warmth and sincerity, and kissed Commander Byrd on both his cheeks.

On May 11, at 9 A.M. the Norge, with a crew of seventeen, took off. Amundsen had different plans for her. He would fly from King's Bay, Spitzbergen, across the pole and to Point Barrow, Alaska, on the other side — a distance of 2000 miles. From Point Barrow he would make for Nome. At an altitude of 1400 feet and a speed of 64 miles per hour, the Norge hurried through the chilly Arctic air. Head winds bothered her that night and fogs closed in during the early morning of May 12. But later they scattered, and at 3.30 A.M. on May 12 the Norge hovered, like the Josephine Ford

only three days before, astride the spinning earth at a point where every direction is south. Amundsen, Ellsworth, and Nobile descended to an altitude of only six hundred feet, and on stout steel-pointed rods dropped the flags of their countries, while the wireless of the Norge broadcast to the world the news that now both forms of aerial navigation had triumphed. Here was the first wireless message to have been sent from the pole. Not for 153 days after Peary had made the first discovery did the city of New York, in 1909, know what had happened. But on the morning of May 12, 1926, the *New York Times* not only carried the story of Amundsen's flight, but printed on its first page a special dispatch from the correspondent it had placed aboard — and the story by Frederick Raam appeared with a date line unlike any other the world had known before. His story began, "North Pole, Wednesday, May 12, 1 A.M."

But the world was still due for worry, none the less. After the wireless had concluded this broadcast, the fogs that surrounded the ship froze on everything and a blanket of silence was suddenly clapped down on the north. For anxious hours the world waited. Unknown to everyone, the Norge slid silently westward. At 8.15 on the morning of May 15 she sighted Point Barrow. At the settlement of Teller, not far from Nome, a member of the party jumped in a parachute and anchored the ship with the assistance of all the Eskimos in the place, while the wireless through which the world was to be assured that Amundsen, Ellsworth, and Nobile were safe was properly repaired. Once in Nome the expedition was over, and Amundsen had realized an ambition that had been denied him for three-and-thirty years. As for the gallant Norge, they packed her up and sent her to Seattle.

To this diverse list of aerial polar heroes — two Americans, a Norwegian, and an Italian — must now be added two others, an Australian and a second Norwegian. The flight of Captain George H. Wilkins, knighted now for his daring, and Lieutenant Carl B. Eielson ranks with the most daring exploits in aviation history. Reversing the direction of the Norge, Wilkins and Eielson set out to fly from Point Barrow to Spitzbergen. Thirty-three Eskimos shoveled for two days to make a runway of snow 14 feet wide by 5000 feet long over which the skis of the plane could slide. Time after time the ship refused to rise, and dog teams hauled it back again to its starting point. But on April 15, 1928, they did succeed in taking off in the Lockheed-Vega monoplane and flew steadily over a wide polar sea on a route which carried them two hundred miles south of the pole.

Some thirty miles north of Green Harbor, Spitzbergen, a violent blizzard forced them down on Dead Man's Point, and for five days they remained storm-bound and alone on this desolate island with snow drifted four feet high over their runners. When finally they could attempt a take-off again, Wilkins found it necessary to help the engine by getting out and pushing on the tail of the plane. The manœuvre was successful; the plane took off all right enough, but it left Wilkins behind. The watchful Eielson saw, cut the motor, and Wilkins began the back-breaking job all over again. Once again the plane got under way and once again Wilkins slipped off its icy fuselage. The third time all went well. Wilkins and Eielson made Green Harbor, Spitzbergen, after a flight of 2200 miles and after a total of 20½ hours in the air. Not content with that, these same two men, on December 27, 1928, made the first flight over Antarctica.

In the same year Umberto Nobile (by then promoted to the rank of general), who had supervised the construction of Amundsen's Norge, essayed a flight of his own. The sweet concord of nations aboard the Norge had not endured once the flight was over. Amundsen and Nobile had separated, saying harsh things about each other, many of which flamed up later in the newspapers. Nobile felt quite certain that much of the success of Amundsen's flight had been due to him. Now, with his own ship, the Italia, he set out to prove that he needed no Norwegians, no Americans, to make a polar flight successful.

By easy stages the big Italia reached King's Bay, Spitzbergen, from Milan. Two flights in early May established Nobile and the Italia as explorers. The first was not spectacular; the second was 70 hours long and covered a distance of 2375 miles. Much uncharted land was photographed.

Then, on May 23, Nobile turned the Italia's nose toward the pole. One day later her wireless reported her there. One more day, which brings us to May 25, and the Italia reported all well and returning home. A violent storm broke then, but the radio maintained communication for a short time. And after that the most impenetrable shroud of mystery settled down.

For a week no sound was heard from General Nobile or his ship. When hope had been all but abandoned, came a sudden SOS. Ice had formed on the large gas bag. The Italia had become unmanageable and crashed into the polar ice 220 miles from her base. Ten of her crew had been thrown out, one had been killed, and the forward gondola had been wrecked. Out of control and with six men still aboard her, the Italia drifted off to the east. Nobile insisted

later that he saw a burst of flame and smoke, but nothing was ever heard or seen either of the ship or of the men she carried off.

Meanwhile, in response to his desperate plea for help, relief expeditions converged on Spitzbergen by dog team, ice breaker, and by air. Five nations joined the search. Amundsen forgot his quarrel; with René Guilbaud and four other men he set off to the rescue in the French seaplane Latham 47. Tragedy doubled and redoubled, for after one brief radio message neither the gallant Amundsen nor his party were ever heard of again.

It was not until June 20 that the Italian, Major Maddalena, flying a large Savoia seaplane, located a fragment of the party. Thrice before planes had flown over the spot where the injured Nobile lay — they quite obvious to him, he invisible to them. A tent, dyed red to attract attention, finally became visible to Major Maddalena, who dropped 650 pounds of food and supplies by parachute. The ice now was breaking up, and neither a seaplane nor a land plane could be sure of coming down without a crash. Meanwhile, Major Maddalena made another successful trip, dropped more food, tobacco, and clothes.

On June 24, Lieutenant Lundborg, a Swedish aviator, displaying marvelous skill in piloting his tiny ski-mounted Fokker monoplane, managed to land. He found the party completely broken up. Nobile, the chief engineer, and four others formed one group; a second, consisting of Zappi, navigator, Mariano, pilot, and Malmgren, meteorologist, had set off on foot in an attempt to reach the mainland. Nobile knew nothing more about them. Lundborg took the General off to Whal Island, Hinlopen Strait, and went back after

another man. His plane crashed in landing, and the rescuer himself became a prisoner.

At one time or another twenty-four planes were busy with the search and rescue attempts. It became necessary not only to rescue Nobile, but to rescue his rescuers as well. Babushin, a Russian aviator, was lost for five days; Captain Sora and three men vanished for a while completely.

It was the Russian ice breaker Krassin which on July 11 discovered Zappi and Mariano. Malmgren, the third member of the party, had died of exposure. All three men had been on the ice for forty-three days, and for thirteen of these they had had no food.

On July 16 the Krassin recovered Captain Sora and his party, and the melancholy story of the Italia was ended — save for the wild and bitter rumors which to this day suggest not only criminal incompetence and heartlessness, but even cannibalism. In one fashion or another, twelve men had perished.

Slowly the unhappy memory faded from the public's mind. And then, two months later, off the Fuglö Islands, a curious bit of floating wreckage was picked up. It was a pontoon from the plane in which Roald Amundsen had set out months before to rescue his bitter enemy.

XXXI

THE HUMBLED OCEANS

By every omen the year 1927 was to have been a bad one in the history of aviation. For seven years there had stood unchallenged a prize offer made by Raymond Orteig to the first man who would make a nonstop flight not merely across the Atlantic Ocean, but between the cities of New York and Paris.

Seldom had any challenge waited so long for the gage to be thrown down. Nineteen hundred and nineteen vanished. One by one the early 1920's did the same. Then came 1926. In that year René Fonck, ace of aces in the French Army during the war, made the first try for the cash, the glory, the recognition, of making a city-to-city hop across 3000 miles of land and water. His attempt ended in violent tragedy. On September 21, 1926, his heavy-laden Sikorsky plane crashed on Roosevelt Field when, at the end of the runway, it could neither take off nor stop. The flames from the wreckage shot fifty feet high; Fonck and Lieutenant Lawrence W. Curtin, U. S. N., escaped alive, but Jacob Islimoff, mechanic, and Charles Clavier, radio operator, were killed.

This grisly disaster effectually dampened the ardor of any others who had thought in that year to compete for the Orteig prize. But once 1927 was well under way and this original

disaster had been forgotten, the history of aviation again took a morbid turn. On April 26, 1927, in the course of a trial flight the plane American Legion, a candidate for non-stop transatlantic honors, crashed in Virginia, carrying Lieutenant Commander Noel Davis and Lieutenant Stanton H. Wooster of the United States Navy to their deaths.

To cap the climax of disaster, the two French aviators, Charles Nungesser and François Coli, vanished somewhere in the Atlantic Ocean after having taken off for an east-to-west hop on May 8.

While all this dramatic preparation was still fresh in the public mind, the contest for the Orteig prize assumed new proportions. Commander Byrd and three companions proposed to compete for it in their tri-motored Fokker, the America. Clarence Chamberlin, still backed by Charles A. Levine, sought for the $25,000 in the Bellanca monoplane Columbia. For days the newspapers had been filled with the stories of the trial flights and tribulations of these two teams. Then there floated down to challenge them for the honor a third and almost unheard-of-pilot. His name was Charles A. Lindbergh, known as Slim by his intimates, but referred to by the papers of the day as the "Flying Fool."

The world was ready for aeronautical miracles. The disaster to Fonck, the disaster to Davis and Wooster, the loss of Nungesser and Coli, a significant although not serious accident to Commander Byrd and his party, all impressed upon the public mind the danger and difficulty of winning the Orteig prize. Dramatic necessity demanded a Lindbergh — and got him.

The newspapers of the days immediately preceding Lindbergh's rise to fame make curious reading now. First, the

great New York dailies casually noted that a new contestant was about to enter the contest for a successful nonstop New York to Paris flight. The first real attention that was paid to this lad of twenty-five came when he made his flight from San Diego to New York, with a stop at St. Louis, in the fastest time that had been yet recorded for a coast-to-coast flight. No sooner did he land in New York than he became front-page material. His youth, his smile, his shyness, and, above all, his amazing determination, made everyone his friend.

Yet, although everyone liked him, few believed in him. Strain and pessimism were in the air. Nungesser and Coli had been lost only a few days before. "Their experience, whatever it proved to be, will not affect my plans," said Captain Lindbergh calmly. While he was saying this, General Duval, in France, had this to remark of the attempts to win the Orteig prize: "These attempts are both immoral and shameful. Neither sport nor science is furthered by them." And said a well-known Canadian ace: "It is a physical impossibility for one man to pilot an airplane across the Atlantic." A correspondent of the *New York Times* added to the happy note of optimism by reporting, "In Government circles, Lindbergh's venture is termed suicide."

As a boy, Charles Augustus Lindbergh had satisfied his longing to do things in the air by rigging an old bicycle in a tree and pedaling furiously in the breeze. When he grew up he attended the University of Wisconsin for a short time, without in any noticeable way affecting it or himself. Then he attended a flying school in Lincoln, Nebraska, did barnstorming, stunting, and gypsy flying, and early became a member of the Caterpillar Club by saving his life several times through forced parachute jumps. In 1925 he was grad-

uated from the Army Aviation School in San Antonio. Thereafter he became a pilot with the Mile Hi Airways of Denver, and later a pilot for the Robertson Aircraft Corporation — a St. Louis concern which held the contract to deliver mail between its home city and Chicago.

For a long time Slim Lindbergh had known that he would some day fly the Atlantic. He worked and planned; by the early part of 1927 he had achieved results. Eight business men of the St. Louis Chamber of Commerce aided him. Into the bargain he had poured out his own savings and had purchased for $13,000 a Ryan monoplane with a wing spread of 46 feet and a chord (that is, a width of wing) of 7 feet. It weighed 5135 pounds, including one ton (425 gallons) of gasoline, which its tank would hold. Its 223-horsepower Wright Whirlwind motor worked at a speed of 1800 revolutions per minute. In honor of the city to which he owed most of his capital, Captain Lindbergh called his plane the Spirit of St. Louis.

On May 20, 1927, while the airplanes of Byrd, Chamberlin, and Lindbergh stood leashed impatiently on their landing fields, the Weather Bureau reported a "high" — which is to say an area of high barometric pressure, indicating good weather — over the North Atlantic. Lindbergh was the quickest of the three. By quarter of eight in the morning, he shut himself into the closed fuselage of his plane. Regretfully he rejected the company of the small kitten which had made friendly gestures toward him during the preceding days, unmistakably indicating that it would be glad to favor him with its companionship on what was to be, even for a cat, a trying and monotonous spell. This was to be a solitary flight.

At 7.52 in the morning, with no display, no ostentation, and without saying any of the things that were credited to him afterward, Lindbergh took off. He carried with him five sandwiches and two canteens of water, and he said " So long " as casually as if he had been going for a street-car ride. By way of explaining who he was — a formality which he believed would be necessary and perhaps difficult — he carried with him several letters of introduction.

By what seemed a few narrow inches the wheels of his plane cleared a clump of trees at the end of the runway. He dwindled and vanished. Cape Cod heard the drone of his engine a few hours later. At half-past seven in the evening, the silver wings of a monoplane flashed over St. John, New Brunswick, and disappeared toward Newfoundland in the fog. Another challenge to the offer of Raymond Orteig had begun. Lloyd's showed what they thought of the venture by quoting odds of ten to three that Charles Augustus Lindbergh would never be seen again.

In the next eleven hours the *New York Times* answered, as best it could, ten thousand telephone inquiries from people who wondered where this vanished young man and his silver monoplane might be.

Now over the Atlantic, Lindbergh had occasional flashes of visibility in which he saw only a cold, gray, berg-strewn ocean. Sleet added to the other dangers of the flight. He tried to fly above it and could not. He tried to detour around it and could not. Almost halfway across he wrestled with the temptation to turn back — and kept resolutely forward only because he realized that he had probably now a shorter distance to travel to Le Bourget than to New York. Two hours later the weather cleared, and Lindbergh faced an enemy almost

as deadly as fog or storm or sleet. This new enemy, through the long hours of the night of May 20, was monotony.

With dawn Lindbergh spied a craft below him. Down upon a crew of astounded fishermen he zoomed and shouted to them, " Which way is Ireland? " The noise of his engine drowned him out; when he found his missing island an hour later it was solely by virtue of his own navigation.

Two hours farther on, the Spirit of St. Louis flashed over England. The weather was clear now and the sun was setting as Lindbergh steered his course over that same English Channel which Louis Blériot had flown in the reverse direction eighteen years before. He saw the airway beacons of the London-Paris lines. The brilliant Eiffel Tower flashed lightning, and spelled out over and over again the word " Citroën." He saw the myriads of red and green neon lamps make the streets of Paris glow. But he had no maps to tell him where this Le Bourget Field might be.

He circled several broad circles about the city, and at last spotted the lights of the landing field he had been seeking. Then it was that, after traveling 3600 miles in 33 hours and 39 minutes, he landed in the midst of an uproar the like of which had never before and may never again issue from the throats of a mob delirious with joy and with congratulation. " Surround him and isolate him," the editors of the *New York Times* had told their correspondents, anxiously scanning the skies for the approaching plane. Surround him? Isolate him? The surrounding was done by a crowd of 100,000 people, many of whom had waited seven hours for the sound of his engine in the sky and all of whom came close to crushing him to death as soon as he landed. He was borne on the shoulders of a mob whither it listed, while still another con-

tingent sought, despite the best efforts of the Paris constabulary, to demolish the Spirit of St. Louis, almost before its whirling propellers came to rest, in their mad rush for souvenirs.

The isolating by some trick of magic was done by two French aviation officers. Then Ambassador Myron T. Herrick got his hero somehow to the United States Embassy, supplied him with pajamas, barricaded the doors against a rioting mob, and cabled to an anxious lady in Detroit, Michigan, U. S. A.: "Warmest congratulations. Your incomparable son has honored me by becoming my guest. He is in fine condition and sleeping sweetly under Uncle Sam's roof."

Thereafter Charles Augustus Lindbergh lived up to the lines of Rudyard Kipling. He walked with crowds and kept his virtue; he talked with kings and did not lose the common touch. He called on that brave French pioneer of the air, Louis Blériot. He called also on the mother of the lost Nungesser. President Doumergue of the French Republic decorated him with the Cross of the Legion of Honor. The French nation forgot its sorrow in paying homage to the extraordinary, simple, youthful, unaffected young American, who, with no ado whatever, had climbed into the cockpit of his plane and flown the breadth of the Atlantic single-handed and alone.

For a week Charles Lindbergh stayed in Paris, a virtual prisoner of the mob. During this time, offers from moving-picture and other impresarios piled up on his doorstep to the extent of $700,000. He refused them all. Finally released from Paris, he journeyed to Brussels and met King Albert of Belgium. Then he flew the Spirit of St. Louis across the Channel, and at Croydon Field, outside of London, he was

met and mobbed by half a million people. When he had recovered from this, he was presented to King George V and Queen Mary. Finally, on June 5, on the United States cruiser Memphis, he sailed for home. His welcome in Washington on June 11 and in New York on June 14 was a tribute the like of which no other citizen in the history of this country had ever before received. There were, say statisticians, between three and four and one-half million people thronging the streets and choking the windows of New York to see their national hero ride uptown.

The prize was won. The glamour of any future transatlantic flight was already worn away by the magnificence of Lindbergh's achievement. Notwithstanding, at 6.05 A.M. on June 4, 1927, the Atlantic was attempted again. This time it was Clarence D. Chamberlin, in the Bellanca monoplane Columbia, who made it. Previously he had earned great honors as winner of a world's record for endurance of 51 hours, 11 minutes, and 25 seconds. Thereafter his splendid talents as a pilot were somewhat obscured by the propensities of his backer, Charles A. Levine, for quarreling, one by one, with three of Chamberlin's proposed partners on the transatlantic flight.

After Levine had fired the last of these companions, mystery set in. Chamberlin, everyone knew, was not to make the flight alone; yet the identity of his companion was carefully shrouded in mystery until, on June 4, Levine himself climbed into the plane and the two men sped away from Roosevelt Field. Until that moment not even Levine's wife had an inkling of what was to happen.

Lindbergh had made Paris; Chamberlin and Levine headed for Berlin. Beyond Trepassey Bay they struck fogs and ice-

bergs as had Lindbergh. On the day following their take-off they sighted the Cunarder Mauretania about four hundred miles off the English coast. They circled her, waved to passengers, and sped on. In the late afternoon they sighted Land's End in England and at 8.45 in the evening they cut across the southwest corner of the island. The weather, which had up to now been clear, turned cloudy. Belgium was shrouded in a shawl of fog. Over the River Rhine the weather cleared. Chamberlin zoomed low to question which way lay Berlin. Unhappily, at seven o'clock in the morning of June 6, the last drop of fuel vanished from the tanks and Chamberlin made a landing at what later turned out to be Eisleben, 118 miles distant from Berlin.

Chamberlin refueled and tried again. On his next hop he lost himself in the darkness, and then, under the impression that he had flown far enough, he came down suddenly in a marsh at Kottbus, 65 miles distant from Berlin. The burgomaster, trailed by the entire population of the town, turned out to welcome the fliers. With a new propeller to replace the one shattered in landing, Chamberlin took off, and on June 7 landed before a crowd of 150,000 people at Tempelhofer Field. Although their city to city record had not been held intact, Chamberlin and Levine had made a nonstop flight of 3911 miles in 42 hours and 45 minutes, and had thus set up a new world's long-distance record.

Next, Commander Byrd took off from Roosevelt Field in his tri-motored monoplane America on the flight that was backed by Rodman Wanamaker — the same Rodman Wanamaker who had, in 1914, cherished the ambition of spanning the Atlantic through the air before the flame of war had set all Europe afire. Commander Byrd had a crew of three

besides himself. For pilots he had Bert Acosta, one of Chamberlin's former partners, and Lieutenant Bernt Balchen. Lieutenant George O. Noville was at the radio. The America took off from Roosevelt Field in a pelting rain at 5.24 A.M. on June 29, 1927. The weather was clear when they passed Nova Scotia, but the fog which closed down on them there stayed with them for almost every moment of the remainder of the voyage. For nineteen hours they saw neither land nor sea nor sky; they flew through this thick, enveloping blanket of mist so dense that they could scarcely tell night from day.

Glimpses of the sun helped them on the afternoon of their second day out. The wind was with them, and when their wireless picked up the French liner Paris, which gave them their position, they had, they thought, enough gasoline to fly to Rome. But once beyond Brest on their way to Paris, fog folded in on them again, and darkness, storm, and rain, one by one, added their contributions to the fliers' problems. They saw a revolving light; Byrd took a far chance and radioed Rodman Wanamaker that he was over Paris. The fliers descended, only to find themselves once again over water. Their compass was wrong; they had been traveling in a circle.

Now they tried again for Paris by dead reckoning, but no lights showed to welcome them through the heavy mist. Fuel by now was almost gone. In final desperation they turned back to that revolving beam of light, and, there being nothing else they could possibly do, they landed. With a crash that wrecked her once and for all, the America struck the water 200 yards from shore. Byrd and Noville, Balchen and Acosta, clambered from the cockpit and emerged dripping on the beach of Ver-Sur-Mer — a tiny village on the Norman coast. An inflated rubber boat had saved their

lives (which Lloyd's had insured for $200,000) and had been the means also of rescuing the ship's log and the first official mail ever to be carried through the air across the Atlantic Ocean.

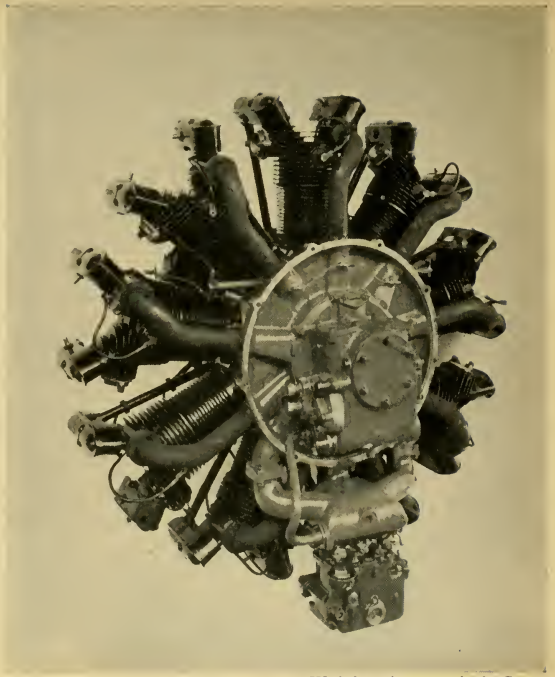
Two more Americans, before this eventful year was over, added their names to aviation's roll of honor. They were William S. Brock and Edward F. Schlee. Their ambitions went further than the mere spanning of the Atlantic. They were anxious to beat the flying time which the round-the-world fliers had made in 1924. From Harbor Grace, Newfoundland, they took off on August 27 in their Stinson-Detroiter monoplane Pride of Detroit. In 23 hours and 9 minutes they made a distance of 2358 miles to the Croydon airport in London through rain, fog, and wind. Thereafter their route took them to Munich, to Belgrade, to Constantinople, Bagdad, Bandar Abbas, Karachi, Allahabad, Calcutta, and Rangoon. Here the fliers had a battle with the winds and made for Hanoi instead of Bangkok. Despite protests that their flight was too hazardous to justify, they reached Tokyo on September 14. The Detroit Chamber of Commerce had cabled urging them not to attempt the Pacific. The Navy Department refused to span the ocean with its destroyers; Assistant Secretary of the Navy Warner warned the fliers against a hop of extraordinary dangers. In the face of half a dozen dissuasions Brock and Schlee gave up their flight, after having made 12,295 miles in 18 days, with no advance preparation along their tortuous and unfamiliar route.

The further record in spanning the Atlantic in 1927 was not so happy. In some measure this was due to the fact that the flight from Europe to America, east to west, is contrary to the

International

THE FRIENDSHIP

Amelia Earhart's Plane Seeks Information from the S. S. America (*Page 313*)



Wright Aeronautical Corp.

WRIGHT WHIRLWIND J–5

The Famous Engine That Holds Most Records for Endurance

WIND TUNNEL

Used at Massachusetts Institute of Technology for Aerodynamic research

THE LOS ANGELES

The Mammoth Dirigible of the U. S. Navy (*Page 279*)

direction of the prevailing winds, as Charles Green and John Wise had been the first to notice. Nungesser and Coli had left Le Bourget on May 7, were reported over England and Ireland, and then never heard of again. On August 31 the plane St. Raphael left England bound for Ottawa. Aboard her were Captain Leslie Hamilton, the Princess Lowenstein-Wertheim, and Colonel Frederick Minchin. That plane, with the skeletons of its passengers, lies somewhere at the bottom of the Atlantic to-day. So do the passengers of the Old Glory, a plane whose flight was financed by William Randolph Hearst and which carried Lloyd Bertaud, J. D. Hill, and Philip A. Payne, managing editor of the *New York Daily Mirror*. On September 6, 1927, the Old Glory took off from Old Orchard, Maine. That same evening an SOS flashed from the Newfoundland coast. Next day the S. S. Kyle sighted a patch of oil on the heaving waters of the Atlantic. It found the wreck of the Old Glory, but two days of cruising revealed no trace of the bodies of its fliers. Only a day later the plane Sir John Carling vanished on the way from Newfoundland to England, carrying Captain Tully and Lieutenant Metcalf.

"A ship with a woman ain't got no luck." So had said the sailors of that more prosaic element, the water. In some measure this seems to apply to the sky as well, for of the seven planes which set out on transoceanic hops carrying a woman, four were never heard of again, and two — those of Lilli Dillentz and Ruth Elder — failed in mid-ocean, although not with fatal results. Only Amelia Earhart on June 17, 1928, in a three-motored Fokker monoplane, with Wilmer Stultz as pilot and Louis Gordon as mechanic, reached her goal. In choking fog, flying by dead reckoning all the way, Stultz

held his course and came down beyond Ireland, his original mark, at Burry Port, Carmarthenshire, Wales. Stultz was a great pilot and deserved better than his melancholy death a year later. His extraordinary feat in navigation was wholly obscured by the fact that newspapers considered a woman's flight across the Atlantic more notable. Perhaps it was.

Not until April 12, 1928, was the Atlantic first crossed from east to west. Then the Junkers monoplane Bremen, German built, left Baldonnel Airport, Dublin, Ireland, bound for Mitchel Field. Aboard her were two Germans and an Irishman — the Baron Gunther von Huenefeld, Captain Hermann Koehl, and Commandant James Fitzmaurice. The Bremen fought violent storms for more than a day. In a storm, and far out of its course, it crashed on Greenely Island, Straits of Belle Isle, after thirty-four hours in the air. The radio operator at Point Amour on the mainland of Labrador, twenty miles away, picked up a message of distress, and on April 15 the searching planes of Schiller and Cuisiner located the lost fliers.

On the desolate island where they had landed there lived only seven families. Attempts to get the Bremen off failed because of a lack of parts and facilities for repair. Rescue attempts cost the life of Byrd's partner in the Polar flight, Floyd Bennett, who died on April 25 of pneumonia. At last, on April 26, the crew of the Bremen left for civilization. The Bremen itself to-day hangs in the Grand Central Station in New York City, the first plane to have spanned the Atlantic on a non-stop westward hop.

The story of man's success in linking continents by air goes forward now too swiftly to be recorded. Before 1929 was half over, the Atlantic had been flown twice again. On June 13,

1929, Armeno Lotti, Jean Assollant, and René Lefevre took off from Old Orchard in the monoplane Yellow Bird, after the sketchiest of preparations. They were bound for Rome, but the unknown presence of a young stowaway, whose name is not worth recording, hampered them so seriously that after battling constant storms they descended at Santander, after covering 3128 miles in 29 hours and 52 minutes. So commonplace had ocean hops now become that only three hundred people (excluding fifteen hundred Agents de Police, who had been detailed to handle the expected mob) were at Le Bourget Field to meet them when they finally arrived.

Side by side with the Yellow Bird at Old Orchard Beach had stood the plane Green Flash which the Americans, Roger Q. Williams and Lewis A. Yancey, had likewise sought to fly to Rome. Despite their careful preparations, the Green Flash crashed on her take-off. Williams and Yancey procured another plane, the Pathfinder, and in it, on July 9, after a flight during which they never saw the sea for more than two hours at a time, they, like their predecessors, came down at Santander. Their flight lasted 31½ hours. Later, they made their final destination in another hop. That ended the Atlantic crossings by airplane for 1929.

Between May 1919, when Harry Hawker made the first attempt, and mid-July 1929, thirty-two airplanes attempted to fly the Atlantic. Of these, eleven succeeded. In them, twenty-six men and one woman successfully linked America and Europe by air. Disaster in one form or another overtook all others. Obviously the day, even now predicted, when planes flying at 25,000 feet altitude and making 300 miles per hour will leave New York at five in the afternoon and deliver their passengers in London for breakfast the next morning

has not yet come. But it will, as surely as the Wrights flew at Kitty Hawk.

It took sky trail-blazers longer to bring their ambition and their courage to the point of flying the Pacific; yet the Pacific, in the light of experience gained on the Atlantic, proved to be the less stubborn ocean.

The first attempt to cross it by traveling from California to Hawaii came in 1925. In that year the longest recorded seaplane flight was not much over 1200 miles. It was daring in the extreme, therefore, to attempt to span the 2100 miles of open water that lay between the west coast and Hawaii.

Yet on August 31, 1925, two seaplanes flashed their way out the Golden Gate on just such a voyage. One almost immediately got into trouble and was towed back. The other, in charge of Commander John Rodgers, U. S. N., swept on. For pilots he had Lieutenant Byron J. Connell and Chief Aviation Pilot S. R. Pope. The plane's radio was operated by Chief Radioman O. G. Stantz. Their plane was the PN-9 No. 1 — P for patrol, N for Navy.

After three hours of flying, twilight overtook them. The crew saw a destroyer below and knew that they were on their course. But by ten o'clock the next morning it became evident that winds had hindered them so much that the fuel was insufficient to take them to Hawaii. With the last drop of gasoline gone, the PN-9 No. 1 came down gently and squatted on the calm Pacific. Their radio would receive messages, but it could not send them without power. The crew had the maddening experience of listening to searching destroyers exchanging dispatches about them without being able to answer back. They saw no sign of smoke on the horizon for two

Wide World

AUTOGYRO

This Unique Type of Aircraft Seems to Have Great Future Possibilities

ALL METAL

One of the Giant Ford Planes Used by Transcontinental Air Transport in Air-Rail Cross-Continent Passenger Service

Underwood & Underwood

REVOLUTIONARY DIRIGIBLE

The All Metal Steam-Driven Ship City of Glendale Now Under Construction

days — and then a ship passed by, serenely and unknowing, a mile away. By now their plight was serious. Food was mouldy, water was scarce. It was obvious from messages they heard that ships were hunting on the wrong course. With a sail made from fabric ripped from the lower wings they managed, however, to make about fifty miles a day in the direction of Hawaii. Hope all but vanished when they heard the Navy ships talking about giving up the search. Finally, however, the army searchlights on Oahu came into view and they knew that they had still a chance for life. They steered for Kauai — farther distant, but with a harbor which Oahu's rocky shores did not offer. Yet even close at hand danger still threatened them. They were all too weak to swim. If their ship was blown on the rocks during the night, they would perish as surely as in mid-Pacific. But smoke signals of distress made from burning wing fabric in a bucket finally brought them attention. The submarine R-4 saw the plane and threw a line to four famished men with tropical growths of beard. It supplied them with food and five gallons of water. They were nine days out from San Francisco; they had flown 1870 miles and sailed 450. To his mother Commander Rodgers immediately cabled, " Sorry to have given you so much cause for worry." The Pacific remained phlegmatic and unconquered.

The first successful transpacific flight came in 1927. On June 28 of that year, as quietly as Lindbergh had hopped for Le Bourget, Lieutenants Lester J. Maitland and Albert F. Hegenberger, U. S. A., took off from Oakland, California, in a large tri-motored Fokker monoplane. In 25 hours and 50 minutes they made the 2400 miles which separated the Oakland airport from Wheeler Field, Honolulu, and realized a

dream of Maitland's that had been of six years' standing. This flight, coming in the shadow of Lindbergh's solitary journey, never received one tenth of the praise that should have been showered on it. Had Maitland and Hegenberger made a mistake of as much as two degrees in their course, they would have missed their destination altogether. No other land intervenes in the Pacific until one reaches the Solomon Islands, 2500 miles farther away. But they had flown straight and true, and achieved the longest overwater flight yet made.

A fortnight later their exploit was repeated by Emory Bronte and Ernest L. Smith in the City of Oakland, who made 2340 miles from Oakland to the island of Molokai, Hawaii, in 25 hours and 36 minutes.

Then, on August 16 and 17, entrants in the Dole flight took off, hoping, all of them, for the first prize of $25,000 or the second of $10,000. Art Goebel and William Davis, flying the Woolaroc, came first with a time of 26 hours and 17 minutes to Honolulu; Martin Jensen and Paul Schulter in the Aloha came in second with 28 hours and 16 minutes. Yet the flight roused a storm of protest. In all, there had been fourteen entrants. Eight crossed the starting line; four turned back because of fog. Of the remaining four, only the first and second prize winners arrived. The other two planes were lost at sea, one of them carrying a woman (Mildred Doran, school-teacher) to death. In all, the Dole race cost ten lives.

In May of the following year, 1928, there came the amazing flight of the Southern Cross. Two Australians, Captain Charles Kingsford-Smith and Captain Charles Ulm, were pilots. The United States was represented by Navigator Harry W. Lyon and Radio Operator James Warner.

After long and careful preparation these four took off from Oakland on May 31, 1928, in their tri-motored Fokker. For them a successful landing in Honolulu was not the completion of their journey — it was no more than the first hop, and not the longest one. Their next, to Suva, Fiji Islands, was 3138 miles, all over water. Nothing like it had ever been attempted before. The first half of this hop was made under favorable conditions. With the coming of night, however, head winds and a violent rain rose up to plague them. The air was bumpy, the stars obscure. There began a desperate battle against time which was finally won when the Southern Cross landed at Suva after 34 hours and 33 minutes in the air. This amazing plane with its indomitable crew had now made 5538 miles in two hops. In a third hop it accomplished 1762 miles more and reached Brisbane, Australia, after bucking storms all the way. And at 10 A.M. on the morning of June 9 the Southern Cross completed its triumphal journey from Oakland to Australia by landing safely at the metropolis of Sydney. Many fliers believe the flight that ended then to be the finest yet recorded in the history of aviation. Time can scarcely dim its lustre.

XXXII

TO BE CONTINUED

Should there be a chapter on the future of aviation? There should not. Prophecy is always dangerous. Prophecy having to do with a science whose growing history is rewritten every day is almost suicidal. Who is there presumptuous enough to believe that he can predict the forthcoming wonders of a science which already, within twenty-six years of its birth, challenges many arts and philosophies that are more than ten times as old? The next few paragraphs are for those who believe in prophecy.

In the *Cosmopolitan Magazine* for February 1893, Julian Hawthorne indulged himself in fancy by saying that by the time another century had gone by it would have shown the dawn of aerial navigation to an extent which would permit business men to live fifty miles from their offices; make war too terribly destructive for men to dare to fight; concentrate all manufacturing and commercial interests of the country in a few limited centres. In his imagination he went on: "In no other part of the country is there so much as a single village. Every family lives on its own lot of land, averaging about an acre, and the old crowding of people together [in cities] is forever done away with. Each family consists of from five to ten members who do all their own agricultural

work and make a good deal of their own dry goods and clothing."

One of the most spectacular pessimists in the history of aviation was Professor Simon Newcomb, Ph.D., LL.D., professor of mathematics at the United States Naval Academy and at Johns Hopkins University, a famous astronomer and a one-time editor of the *American Journal of Mathematics*. In 1901 he went into considerable detail over the impracticability of human flight as it appeared to the mind of a scientist. He not only thought that there were good scientific reasons why men could not fly, but he also doubted whether man would gain anything if he could. And this was his fundamental objection to heavier-than-air flight: "If an engine were necessary not only to propel a ship, but also to make her float, — if on the occasion of any accident she immediately went to the bottom with all on board, — there would not, at the present day, be any such thing as steam navigation."

Professor Newcomb agreed to the dirigible. He had to; Santos-Dumont had already flown one. He could, however, and did insist that it was impossible to hope that the dirigible would ever carry passengers or freight.

Curiously, the success of the Wright brothers had no very great effect on Professor Newcomb. Five years after the neglected triumph of Kitty Hawk he wrote, in 1908, that the airplane could never succeed because, for any useful load, the necessary wing area would become unmanageable. He never apparently realized the possibility of more efficient wing sections which would give a greater lift per square foot of area. His second objection was that an airplane could not stop for repairs or adjustment. His third was that an airplane could not navigate out of sight of ground or in a fog. Twenty years

have seldom made any other man of high scientific eminence seem quite as foolish as Professor Newcomb. Fortunately, he did not persuade the world.

And in the same year in which Professor Newcomb first fulminated, Rear Admiral Melville, then chief of the Bureau of Steam Engineering, wrote this of man's attempts to fly: "A calm survey of certain natural phenomena leads the engineer to pronounce all confident prophecies at this time for future success as wholly unwarranted if not absurd."

The record goes on. This is what Thomas Alva Edison said, in 1908: "To get the perfect flying machine they will have to come right back to what I told the reporters years ago [1897] when they asked me to give them my views on that subject. I told them that, whatever progress the airplane might make, the helicopter would come to be taken up by the advanced students of aeronautics."

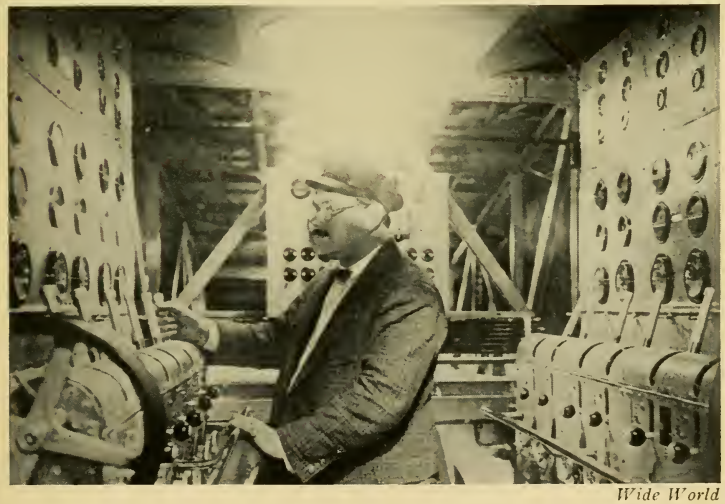
Perhaps; helicopter students are still hard at work, but the principle that provided Leonardo da Vinci with the first model-scale success in the history of aviation remains even yet the last completely unsolved problem — although the "Autogyro" of de la Cierva, which has demonstrated that, alone among heavier-than-air-craft it can hover almost stationary in the sky, brings a strong hint of success for the future.

In a few ways the sixteenth century was saner than the nineteenth. Roger Bacon wrote in the thirteenth century: "More than three quarters of all man's inventive genius has been devoted to just this one purpose of saving time, particularly in the transportation of himself and his possessions from place to place." When man spends three quarters of six centuries in working on one problem, it is reasonable to assume

Wide World

MAMMOTH SEAPLANE

The German Plane DO–X Which Has Twelve Motors, Three Decks, and Accommodations for One Hundred People



Wide World

ENGINE ROOM

From Here Twelve Motors of the Huge Dornier Seaplane DO–X Are Controlled

Wide World

SEADROME

A Model of Mid-Ocean Landing Fields Proposed by Edward R. Armstrong

that some day he may solve it. Yet in 1896 Sir William Thomson, Lord Kelvin, one of the most illustrious practical scientists that the British Isles have ever produced, said, "I have not the smallest molecule of faith in aerial navigation."

And in the face of that incredible blunder, what should anybody say? We must content ourselves with knowing that the future is bright with promise; like the sun, its very brilliance keeps us from seeing it.

Happily, the prophecies of Sir Hiram Maxim and Santos-Dumont that the airplane would find its best use only as an instrument of war are already proved false. Air passenger lines now make a maze of the map of Europe. In this country, where development was slower at the outset, passenger service by plane is already a considerable factor in transportation — so considerable that the Pennsylvania and the Santa Fe Railroads and the Transcontinental Air Transport have linked their services together for regular 48-hour coast-to-coast journeys on a route laid out by Colonel Lindbergh himself.

And the airplane to-day likewise serves a multitude of other purposes which even the Wright brothers never had foreseen on the day they made their first brief but triumphant flight of twelve seconds. Aerial photography is used in mapping, city planning, locating sites for dams, reservoirs, and the like. It supplies the means for a new and effective forest-fire control — in one year, in California alone, pilots have reported one thousand forest fires. The airplane has saved $16,000,000 in one year in the cost of "dusting" cotton as protection against the boll weevil. In twenty minutes it has sown a square mile of grass seed — a task which would take two men three weeks to accomplish. Even in advertising it has

served its purpose. — " Sky writing " and " the voice from the clouds " are familiar to everyone.

To-day the airplane is a safe mode of travel — as safe, let us say, as a railroad was in 1890. Yet it is still not safe enough. There are still too many airplane accidents and the United States has more than its proper share of them. Collisions would at first seem almost impossible in Cayley's " unlimited navigable ocean," yet they have frequently occurred. Structurally, the airplane is now safer than the man who flies it. Many more accidents occur through the carelessness or inattention of the pilot than through a mechanical failure of his plane.

What would Professor Newcomb say could he know that planes are successfully refueled in the air and have already remained aloft more than long enough to fly the equivalent of circling the globe without touching ground? The endurance of motors has now, in fact, outrun the patience of men. In December 1928, the endurance record was 65 hours and 25 minutes. In July 1929 it was 420 hours, 21½ minutes. And the plane "Spokane Sun God" has now completed a non-stop round-trip transcontinental flight of 7200 miles in five days' time.

Transatlantic flights are now so commonplace that the leading aeronautical editor of the country has announced that he will no longer mention them, unless they are hereafter backed up by some definite scientific purpose. Two years after Lindbergh's epochal flight, in other words, the stunt value of an ocean hop has vanished. And the recent exploit of the Graf Zeppelin, one hundred and twenty-seventh ship to be built at Friedrichshafen, in circling the globe in 9 days, 20 hours and 23 minutes of flying time (total elapsed time was

21 days, 7 hours and 34 minutes) has put to shame even the imagination of Jules Verne, whose Phineas Fogg could not do it in better than 80 days.

Fog still remains the great enemy of aircraft, a much more terrible enemy than it is for ships at sea. The navigators of the ocean have resignedly endured it for centuries, but the navigators of the air are fighting to overcome it. The great resources of the Daniel Guggenheim Fund for the Promotion of Aeronautics are behind this attempt. Many other agencies here and abroad are struggling shoulder to shoulder to overcome the same obstacle, and the present major battle in aeronautics is not to make planes faster or stronger, but to make them safer. In this respect the Handley-Page slotted wing, which automatically prevents stalling, is perhaps one of the greatest modern contributions to airplane design.

Of the future of design and of the future of achievement which still stretches into the glorious distance, it is impossible to say more. To-day's new invention is replaced by a better one to-morrow. To-day's endurance record finds itself ancient history next week. To the story of aviation, written at the close of three decades of the twentieth century, it is impossible to write "Finis." Let us acknowledge that the story has barely been begun and that, by way of ending this account, we can only write, "To be continued to-morrow."

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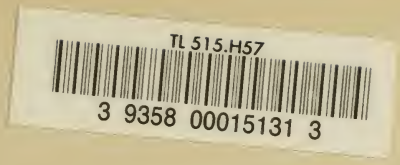

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